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BALL BROTHERS' REBUILT NUMBER 1 FACTORY STRESSES FIRE PROTECTION

By LES AUGBURN
Ball Brothers Company

More than half of the No. 1 Glass Factory Building at the Muncie, Indiana, plant of the Ball Brothers Company, was destroyed by fire on the night of January 2, 1945. The areas of the section which was destroyed were occupied by the paper carton storage on the second floor where the fire started, and by the packing department on the first floor directly beneath the carton storage. The remainder of the building which enclosed the furnace and forming departments was damaged to some extent at the point where the spread of the fire was halted by the intense heat which weakened the over-head steel structure supporting the roof. The buckling of heavy steel girders permitted some parts of the roof to sag down to precarious positions over the furnaces and forming machines. This made it necessary to complete repairs on the damaged section of the old building before construction could be started on a new building to replace that part which was left in total ruin. A new, modern, two-story, brick structure has been erected to replace all areas destroyed by the fire and the plant has been operating at full production for more than a year.

Two large melting furnaces were in operation in the old building at the time of the fire. One furnace supplied glass to seven forming machines, and the other one which was the larger of the two supplied eight machines. The larger furnace had been in production only a short time when the fire occurred. At that period the demand for glass containers was at its war-time peak. Therefore, the first concern of the officials of the company, upon observing the rapid spread of the fire, was the critical war-time need for food packaging containers, the possible loss of customers, and the dislocation of employment to those working in the plant by this rupture of production. Since the smaller furnace had been in capacity operation over a two year period and was rapidly approaching the end of it's expected productivity, the officials decided to shut off the fires in this smaller furnace and direct the efforts of the firemen towards protecting the new and larger furnace and forming equipment of both. The decision was based upon the possibility of making necessary repairs and quickly constructing temporary shelters over the fire affected areas and bringing the new furnace back into production at the earliest possible moment after such repairs could be made.

As stated before, the fire started in the second-story paper carton storage. The floor space was considerably greater than that of the packaging department on the floor below, and was filled to capacity with folded, corrugated-paper, packing cartons and carton partitions made of the same materials, tied up in small bundles. The fire spread rapidly, with great intensity, and developed terrific heat. The partition between the carton storage and the area high above the furnace and the forming departments, was one of medium gauge, corrugated sheet metal against which cartons were stacked. Obviously, such a partition could not long withstand the ordeal of fire to which it was exposed. When it crumpled and fell in, the exposure of heat was extended to the steel roof supports over the furnaces and forming machines which caused the buckling and roof sagging at that point. As you can guess, protective fire walls became requisites in new building planning even before the fire burning up the old one had been extinguished.

Our own factory employees and foreman reporting for work on the six o'clock (a.m.) shift, on the morning of January 3rd, attacked the wreckage, many of them under their own initiative, with energy that boosted morale and was inspiring to those of the officials of the company who had remained at the scene. All available trucks and wheel barrows were pressed into service to haul out the fire-charred, water-soaked debris from beneath a dangling network of twisted steel girders and smaller supporting members which made up the upper structure of the building. The task seemed hopeless.

Inside truckloading dock at rear of Packing Department.

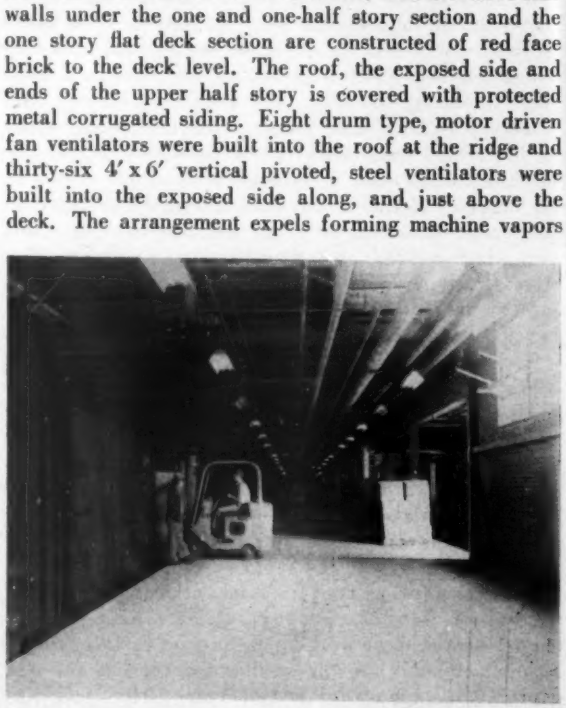
In a matter of hours after the fire had been extinguished, engineers from the Cleveland, Ohio, office of the Austin Company had been called in and were making surveys towards temporary repairs for quick resumption of production from the furnace which was still intact. While no credit had been claimed for performing a miracle, this Herculean undertaking was accomplished in exactly twenty-one days after the date of the fire. Production was resumed on the one furnace, January 23rd.

The war-time labor market was extremely short and presented the greatest obstacle towards quickly completing the repair job, as well as the erection of the new building after the repairs had been made. All available skilled labor was drawn from Muncie and surrounding cities to cut away and remove the dangling steel frame work, to shore up the sagging roof and to replace the new steel structure to support it. Ball factory employees assisted in building a temporary shelter over the lehr section, and to lay 30 lb. asbestos felt, mopped in hot asphalt, over the carton storage, concrete floor to make a weather-proof roof over the packing department below. Wide strips of burlap were attached to the packing department ceiling and brought down to the floor to enclose the working areas of that department. Tables for carton assembly, formerly located on the second floor, were set-up between the lehrs at the selectors stations. The installation of temporary lighting fixtures and heating equipment just about completed the repair job. While the repair job was in progress, however, machine repair men reconditioned the forming machines and millwrights dried out and repaired the lehrs—all accomplished in near zero temperatures and in twenty-one days.

In the meantime the officials of the Ball Brothers Company and Austin Company engineers were burning midnight oil completing plans and specifications for the new building. Three prime factors governed the planning: a fire proof building, modernization, future construction and expansion policy. Of course, a large number of secondary objectives were worked into the broad plans and building design, such as: (1) Increased floor space to include carloading and truck loading docks. (2) Location of test room, gas meter and switch gear rooms, elevator, stairways, offices, rest rooms and cafeteria in relation to future construction policy. (3) Doors, windows, lighting, heating, ventilating and safety devices to insure the best possible working conditions for the employees. (4) An underground belt conveyor system to take cullet from back of the lehrs to the batch system. (5) An overhead automatic sprinkler system as an added safeguard against the reoccurrence of a disabling fire. (6) Increased floor space in the second story carton storage for the location of pre-sealing machines for assembled packing cartons. (7) A countless number of minor details to reduce occupational hazards, to improve working conditions and to increase production.

The overall length of the building runs from north to south and the arrangement of departments in that order is furnace, forming, lehr and packing. New construction begins at the junction of the forming and lehr departments and extends back (south) to include the lehr, packing, and second floor carton storage departments. Side and rear elevations of the new section of the building follow a general trapezoid pattern with a part of the rear wall forming the non-parallel side of the trapezoid. This design was adopted to conform with existing plant passageways and to employ the use of maximum floor space to include the inside truck-loading and carloading docks which are located within the packing department area.

Measuring back (south) forty-four feet from it's junction with the old building, new construction is held to one and one-half stories in height with a lateral one-fifth pitch gable roof covering the area. Extending back an additional twenty-feet construction is dropped to one story, the roof of which is a flat reinforced concrete deck, running the full width of the new building parallel to the one and one-half story section, and which is covered with thirty pound asbestos felt, mopped on in hot asphalt. The remainder of the building extending back from the deck rises to two full stories. The first floor side walls under the one and one-half story section and the one story flat deck section are constructed of red face brick to the deck level. The roof, the exposed side and ends of the upper half story is covered with protected metal corrugated siding. Eight drum type, motor driven fan ventilators were built into the roof at the ridge and thirty-six 4′ x 6′ vertical pivoted, steel ventilators were built into the exposed side along, and just above the deck. The arrangement expels forming machine vapors



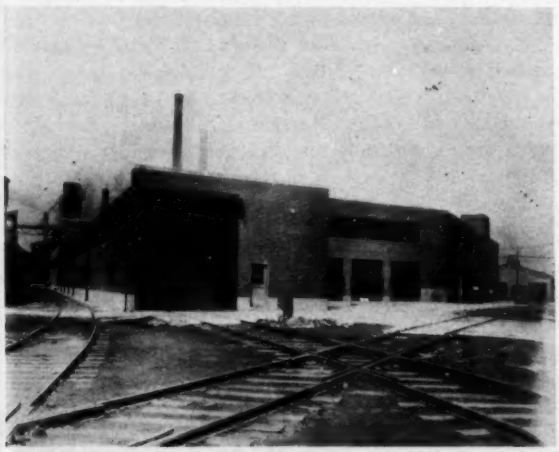
Inside carloading dock west side of Packing Department.

up through the roof ventilators and provides maximum ventilation for the operators of the machines.

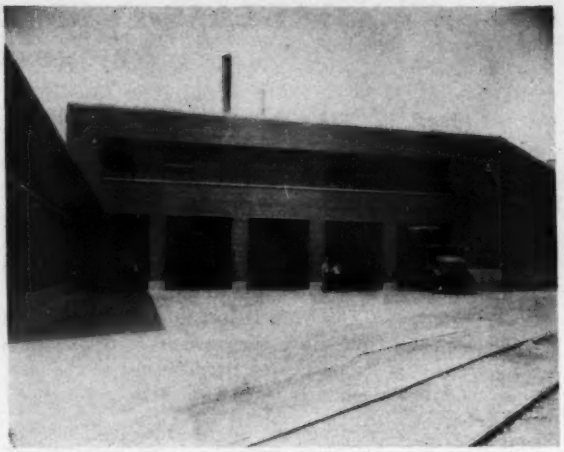
As we have stated, the remainder of the new building extending back from the deck is two full stories in height which includes the packing department and shipping docks on the first floor and the carton storage on the second floor. As an additional fire protective measure, the open space above the one and one-half story section and the one story flat deck section, separates the second floor carton storage from the much higher structure over the forming and furnace departments by a space of sixty-four feet, with the deck area to serve as a base of operations for firemen in the event of a future out-break of fire in the carton storage department on the one side, or in the furnace and forming department on the other side of the deck.

The wall along the carton storage side of the deck is brick twelve feet up from the deck level. All other outside walls are of red face brick, and all roof areas extending back from the deck are of pre-cast light weight reinforced concrete slab covered, with thirty pound asbestos felt, mopped on in hot asphalt. Three six foot high-low bay type roof projections, one sixty feet wide and two fifty feet wide, with rows of pivoted windows on either of each projection provide additional light and ventilation for the second floor carton storage.

A fire proof stairwell was built into the east wall of the packing department, midway from front to rear, with an outside, ground level entrance, off the main plant passageway along No. 1 factory building and rises to a brick, penthouse type of projection above the roof for access to the roof areas. It provides entrance and exit to the first floor packing department, to the second floor carton storage, and to the roof above the carton storage department. The steps, the stringers, risers and railings are all of steel, with reinforced concrete landings. The stairways are wide enough to avoid congestion at shift changing times and to evacuate all second floor employees in two or three minutes in the event of fire. Adjacent to the stairwell is a double drive ramp entrance, into the packing department, off the same plant passageway with electrically controlled over-head doors for trucks and towmotors. This too, may be used to evacuate employees in the event of fire. Immediately beyond the ramp is a second employee entrance door from the plant



New building, rear view (south), showing overhead doors to loading docks.



Entrance to inside truckloading docks south end of new building.

passageway to the packing department. Time clocks for male employees are located just inside this entrance and time clocks for female employees are located just inside the stairwell entrance. The packing department foreman's office, the women's rest rooms, men's rest rooms and a millwright shop also, are located along the east wall of the packing department.

A freight elevator and another all steel stairway is located near the west wall of the packing department directly across from the ramp entrance through the east wall. The new and completely modern cafeteria is located along the west wall of the second floor carton storage. Both carton storage and cafeteria are serviced by this stairway and the elevator.

The inside carloading dock, which accommodates seven railway cars is located along the west wall of the packing department, with an electrically controlled overhead door entrance, at the south end of the building. The test room and the forming department foreman's office are located along the west wall of the new building at the north end of the car-loading dock and adjacent to the lehr section between the forming and packing departments. Future building and expansion policy governed the locations of the carloading dock, cafeteria, test room and forming department office. The possibility of rebuilding and enlarging No. 3 glass factory (located just west of, and running parallel to No. 1 factory) to connect with No. 1 factory was considered. If the policy is followed through, these facilities would serve both factories, or be centrally located in one much larger factory.

The inside truck loading docks which accommodate five trucks are located at the rear of the packing department alongside the carloading dock. Here again electrically controlled over-head doors close in these areas. Formerly trucks were loaded from storage sheds located at considerable distance from No. 1 factory which subjected ware packed at No. 1 for truck loading, to long hauls over rough passageways, with a resultant heavy loss in broken ware, exposure of packing cartons to bad weather and the extra expense of double handling. The measure of economy effected by the use of lift trucks, short hauls over smooth floors, to inside factory loading docks should be extremely obvious.

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GLASS-FORMING SUBSTANCES

By KUAN-HAN SUN*

To laymen, glass is something made from sand. To many scientists, and even to glass technologists, glass is just a product of the fusion of soda, "lime," and silica and, perhaps, a few minor components of other oxides, such as alumina, magnesia, etc. To them, the word "glass" and the fused soda-lime-silicate product are almost synonymous. This view is just as much in error as to consider steel and alloy synonymous. Actually, the term glass should be considered broadly just as the term "alloy" is by the metallurgist, and the term solution by the chemist.

However, even from the scientific point of view, the use of the term glass is arbitrary in many respects. First of all, glass is a vitreous substance. As Huggins, Sun, and Silverman[1] pointed out: "A rigorous definition of a vitreous substance is impossible without the introduction of purely arbitrary quantitative limiting values for the rigidity and the dependence of various properties on direction or for the degree of permanence and lack of order in the atomic distribution. Rather than introduce such arbitrariness, it seems better to consider the term vitreous merely as a convenient descriptive adjective, realizing that there are many borderline cases to which the term may be applied or not, as convenient." These authors defined the vitreous state as "that state in which the arrangement of the component atoms, ions, or molecules possesses a permanence similar to that in the crystalline state and a randomness similar to that characteristic of liquids." The definition is qualitative. Secondly, glass is a thermodynamically unstable substance, that is, if given sufficient time, from a fraction of a second to thousands of years, glass will cease to exist as such. Every glass tends to crystallize. The rate of crystallization depends upon conditions, such as temperature, pressure, electric field, etc. There is a definite lifetime for each glass under a given set of conditions. Thirdly, the formation of a glass is a function of the conditions. Hypothetically speaking, almost any substance can be made into a glass if it is subjected to sufficient "quenching" or rapid cooling in the liquid state from a temperature slightly above its melting point or liquidus temperature, particularly if the size of the glass is not specified.

Hence, it is impossible to define the term glass in a rigorous and quantitative manner. In this paper, any inorganic substance, no matter how microscopic, which is formed under present laboratory conditions (such as high pressure, quick quenching), remains unchanged for a reasonable amount of time, say a few years, and its vitreous nature determined by modern scientific means, such as x-ray or electron diffractions, is called a "glass."

The terms "glass" and "vitreous substance" are loosely used as synonyms. Strictly speaking, glass is a vitreous substance, but the reverse is not necessarily always true. Organic plastics, for example, are vitreous substances but are generally not considered as a glass according to the American practice. The A.S.T.M. Committees[2] prefer to define glass as an "inorganic product of fusion . . ." and plastics as ". . . wholly or primarily organic in composition. . . ." Thus, for convenience, the vitreous substances may be divided into three classes namely: (1) glasses, or inorganic vitreous substances, (2) plastics, or organic vitreous substances, and (3) intermediate vitreous substances which comprise those containing both inorganic and organic constituents such as the recently developed "silicones" or other similar organo-metallic vitreous substances.

In this paper, only Class 1 or the inorganic vitreous substances which we designate by the general name, glass, will be discussed. Classes 2 and 3 are not included. The discussion will be limited only to the formation of glass by various chemical substances under certain conditions. No attempt will be made to explain why and how a glass is formed. Since no systematic study has been made of the subject, the treatment will be incomplete, no doubt, and qualitative.

The Glass and Glass Products Committee of the A. S. T. M. has classified glasses according to the one-, two-, or multi-components of which the glass is composed. An alternative way, which has been adopted in this paper, is to classify them according to their chemical nature, namely: I. Elementary Glasses. II. Oxide Glasses. III. Halogenide Glasses. IV. Sulfide Glasses. V. Miscellaneous Glasses. There are glasses, of course, that can be put into more than one of these groups.

I. Elementary Glasses

A. Sulfur. It is well known that when molten sulfur, preferably at 250°C, is chilled, a rubberlike, transparent product is obtained. This elastic sulfur does not dissolve in carbon disulfide and has a density and other properties different from that of the crystalline forms. Threads of this sulfur can be drawn which can be stretched to about ten times their original length. Whereas rhombic sulfur is made up of S_8-rings, elastic or glassy sulfur is composed of long, irregular S-chains, which are responsible for the vitreous property. Undoubtedly, the elastic sulfur will become a brittle sulfur glass when cooled to low temperature.

B. Selenium. Selenium melts at 217.4°C. When the molten selenium is chilled, a brittle, dark-colored glass is obtained, which, when heated to 70-73°C, becomes a rubberlike substance (Meyer and Sievers[28]) which indicates the existence of long Se-chains, as in the case of vitreous sulfur. Selenium readily forms a glass with sulfur (Merwin and Larsen[27]) and with phosphorus (Robinson and Scott[32]). These sulfur-selenium glasses are used as high-refractive-index media in microscopy.

C. Tellurium. Little information is available about vitreous tellurium. Toepler[41] observed an irregularity of volume changes when tellurium cools from the molten state. He attributed this to the formation of an amorphous plastic variety of tellurium. Morey[29] mentioned that tellurium, like selenium, forms a glass.

D. Oxygen. Wahl[42] reported that liquid oxygen becomes viscous before crystallization begins, and forms a glass if cooled quickly.

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E. Other Elements. Since the introduction of x-ray techniques, many amorphous substances, such as amorphous carbon, boron, silicon, etc., have been identified as partially crystalline. This, however, should not be considered as evidence that these elements cannot form glasses. Mellor[26] stated that vitreous arsenic is formed when arsenic is condensed from the vapor state. With regard to metals, so far no vitreous form has been reported. However, the surface layer of many polished metals, the so-called Beilby layer, has been shown by Beilby[4] and by Finch et al.[10] to be amorphous or vitreous. The evidence should be considered conclusive, because the vitreous layer was observed by Finch and coworkers by means of electron diffraction.

In general, one may conclude that the elementary glasses have no significance of practical use.

II. Oxide Glasses

There are two main classes of oxide glasses: (A) "hydrogen-bond" or hydrogen-bridge glasses, and (B) metal-oxygen "bond" glasses. The glasses of the former type are very weak because of the weak "bond" strength of the hydrogen-oxygen linkage.

A. Hydrogen-Bridge Glasses. Typical examples of this group are vitreous water, HPO_3, H_3PO_4, and a hydrolyzed orthosilicic acid glass. It is well known that water can be supercooled, but rigid vitreous water was not obtained until lately by Luyet[22], who cooled a rapid stream of water to the temperature of liquid air. There is no doubt that the hydrogen bridges are responsible for the glass. The metaphosphoric acid glass is believed by Huggins, Sun, and Silverman[35] to consist of long chains,

$$\begin{array}{c} H\ \ H\ \ H \\ O\ \ O\ \ O \\ \ldots . O P O P O P O \ldots . \\ O\ \ O\ \ O \end{array}$$

kinked in a more or less random manner and connected to each other by means of the hydrogen bridges. The orthosilicic acid glass may be made by hydrolyzing ethyl orthosilicate with a little water. A little hydrochloric acid is added to catalyze the reaction. In a few minutes, a clear, rigid glass is formed which is very possibly a hydrogen-bridge glass. The glass dries in air and becomes a powder after a few days.

B. Metal-Oxygen "Bond" Glasses. In this group lie the majority of the most important practical glasses. If small quantities, say, visible grains, of simple oxides of all possible elements are melted and quenched as rapidly as laboratory technique permits, not all of them will form a glass. As a matter of fact, only a small number of them will form a glass. Although no systematic experimental data are available, the list of glass-forming oxides compiled by Huggins, Sun, and Silverman[17] is probably the best at present. There are: B_2O_3, SiO_2, GeO_2, ZrO_2, P_2O_5, As_2O_5, Sb_2O_3, Bi_2O_3, P_2O_3, V_2O_5, and Sb_2O_5. Perhaps SO_3 should also be added to the list since Gerding[12] observed that SO_3, dissolved in SO_2, polymerizes to a firm and elastic surface skin. The list is subject to changes as new experimental data become known. The most important and effective glass-forming oxides among those listed, so far as their practical application is concerned, are B_2O_3, SiO_2, GeO_2 and P_2O_5. Although there are criteria or rules, such as those by Zachariasen[45], Goldschmidt[13,14], and Sun and Silverman[36], for indicating glass-forming oxides, and there is a qualitative picture of glass structure offered by Warren and his school[43], we have no quantitative data whatsoever to explain why one oxide forms a glass and another does not. The solution to the problem would require a complete knowledge of the geometrical configuration of all the ions or atoms in a glass and their relative binding forces.

For convenience, the glass-forming oxides are called glass-formers. The non-glass-forming oxides can be arbitrarily divided into two groups: the modifiers and the intermediate oxides. The modifiers, as the name implies, can be blended with the glass-former to modify the properties of the glass. Structurally speaking, they weaken the network of the glass. They do not form a glass by themselves and cannot form one when added in too great a quantity to a glass-former. The amount of a modifier that can be added depends on the ratio of oxygen to the positive atom of the glass-former. The ratio hardly exceeds 3.5 for germanate, phosphate, and silicate, and 2.3 for borate glasses under ordinary conditions. It is usually very difficult for the oxides in the intermediate group to form a glass. However, some of these oxides may form a glass with modifiers on one side or may be blended in with the glass-former in greater amount than the modifiers could on the other. The former may be called the glass-forming intermediates and the latter the modifying intermediates. Usually, the glass-forming intermediates are also good modifying intermediates, but not vice versa. Al_2O_3 and perhaps also BeO are typical examples of glass-forming intermediates. Glasses composed of Al_2O_3 and modifiers but having no glass-formers have been reported in the literature. In the study of the phase equilibrium of the system $MgO\text{-}CaO\text{-}Al_2O_3$, Shepherd, Rankin, and Wright[34], Rankin and Merwin[31], and McMurdie and Insley[25] observed glass in their quenched samples. Büssem and Eitel[7] and Akiyama and Sawayama[1] also made calcium aluminate glass with an atomic ratio of Ca to Al of about 0.85 to 1 and Gaubert[11] reported a glass of the composition, $MgO\text{-}Al_2O_3$. Brownmiller[6] observed a quench glass in the system $K_2O\text{-}CaO\text{-}Al_2O_3$ and Insley and McMurdie[18] in the system $MgO\text{-}CaO\text{-}Al_2O_3$ and Insley and McMurdie[18] in the system $MgO\text{-}CaO\text{-}Fe_2O_3\text{-}Al_2O_3$. Beaudry[3] also made sodium and calcium aluminate glasses. A number of aluminate and alumino-beryllate glasses composed of many oxides other than the glass-formers, with melting points higher than 1800° C, have been melted by the author, in the Kodak Research Laboratories, using a temperature no higher than 1400°C. For the modifying intermediates, one may mention ZnO, CdO, PbO, TiO_2, ThO_2, Cb_2O_5, Ta_2O_5, etc., in addition to those of the glass-forming intermediates. To illustrate the point, the highest ratios of oxygen to glass-forming positive atoms in the systems: modifiers–glass-former and modifying intermediate–glass-former are compared in the following table, PbO being taken as typical modifying intermediate in most of these cases:

TABLE I

LIMITING O/M RATIOS IN VARIOUS GLASSES
(M Being the Positive Atom of the Glass-Former)

O/M	*Without Modifying Intermediates (Estimated by the Author)*	*With Modifying Intermediates (References)*
O/B	2.3	5.2 (From a lead glass made by the author[38])
O/Si	3.4	5.3 (From a sodium-lead glass by Merwin and Andersen[29])
O/Ge	about 3.4	5.1 (From a lead cadmium glass made by the author[38])
O/P	3.5	4.7 (From a corex glass cited by Kreidl and Weyl[19])

All the glasses cited in the table can be made by the ordinary glass-making method for a sample size in the neighborhood of about 30 grams. The ratios without modifying intermediates are estimated on the basis of author's knowledge of these types of glasses. They may be changed somewhat if new data are available. The ratio for O/Ge is estimated on the ground that Si and Ge behave similarly in glass formation. For small samples and the quenching technique used in the phase equilibrium studies, much higher ratios have been observed. For example, in the system, ZnO-Al_2O_3-SiO_2, Bunting[8] obtained a glass of very high zinc content by quenching with a ratio of O/Si as high as 15.

With a few exceptions, the oxides that are not included in the lists of glass-formers and intermediates are modifiers. They are Na_2O, K_2O, CaO, SrO, BaO, and many others.

Actually, the groups are not sharply separated. There seems to be a continuous transition from one group to another. The division into glass-formers, intermediates, and modifiers is somewhat arbitrary. It is also interesting to know that the glass-forming nature of a component is closely related to its acidity or basicity, as pointed out by Sun and Silverman[37]. According to them, the glass-formers, intermediates, and modifiers are acids, amphoterics, and bases, respectively.

As discussed above, a glass is generally formed by blending one, or preferably more, non-glass-forming oxides with one or more glass-formers. It is clear that the combinations of components and proportions for glass compositions are tremendous. Considering oxide glasses only, it is obvious that glass is not just a fusion product of soda-lime-silica.

In general, it is convenient to group any oxide glasses according to the chief glass-former introduced. We have, therefore, silicate, borate, phosphate, germanate, borosilicate, silicophosphate, and other glasses. An entirely new nomenclature may be needed as more complicated systems are considered.

In addition to these various possible compositions, the actual glass is more complicated because of the change of coordination numbers of many positive atoms. Among the outstanding examples are B, Al, Ti, and others. There is no doubt that boron assumes the coordination numbers 3 and 4 in almost all the modifier-containing borate glasses. The author has experimental evidence for believing that aluminum and titanium assume both 4 and 6 or higher co-ordination numbers in many glasses. A positive atom which assumes various co-ordination numbers behaves entirely different in its various states of co-ordination and the atoms in these states may be considered as different species.

It is not the intention of the author to discuss in detail in this short article these important oxide glass systems. Rather, emphasis will be laid on other relatively insignificant or rare oxide glasses. However, it should be mentioned that the role of boron and phosphorus oxides (particularly the former) is unique because they serve not only as a glass-former, but also as a good fluxing agent. This is a very advantageous quality.

Among the possible glass-formers, there are no data about CO_2, N_2O_5, and CrO_3. Eitel and Skaliks[9] reported a very interesting glass made of $K_2Mg(CO_3)_2$ under pressure. Tammann et al.[39] also succeeded in making a glass from $NaNO_3$, KNO_3, and $AgNO_3$ by spraying the atomized liquid on a cold plate Tammann and Elbrächter[40], however, were not able to make a $Na_2Cr_2O_7$ or $K_2Cr_2O_7$ glass. Many sulfates, such as Tl_2SO_4 (Lamy[20]), $K_2S_2O_7$, $Na_2S_2O_3 \cdot 5H_2O$ (Tammann[39]) and alums (Morey[29]), (Hibben[16]), have been recorded as forming glasses. Some of the water-containing sulfates undoubtedly have hydrogen bridges serving as the linkages. Pure arsenic oxide glass is usually made under pressure. The author, however, was able to make a beryllium arsenate-arsenite glass by an ordinary glass-melting technique at atmospheric pressure.

III. Halogenide Glasses

Halogenide or halide glasses are similar to oxide glasses, except that fewer glass-formers are noted. The composition for glass formation is relatively limited. The binding strengths between positive and negative atoms are weaker in the halogenide glasses. Consequently these glasses are softer.

A. Fluoride Glasses. So far as present knowledge is concerned, BeF_2 is the only glass-former among the fluorides. The structure of BeF_2 is similar to that of SiO_2, according to Warren and Hill [44]. AlF_3 and MgF_2 may be considered as the intermediates, and the remaining fluorides as the modifiers. Goldschmidt[13, 14] was the first one to make a few alkali beryllium fluoride glasses. Heyne[15] also reported a number of beryllium fluoride-type glasses containing alkali metals, magnesium, and aluminium. All these glasses are not resistant to moisture in the air. A great number of moistureproof beryllium fluoride-type glasses will be revealed in the patent literature in the near future. The author has also synthesized fluoride glasses on thin sheets containing no beryllium but having aluminum and other positive atoms. This indicates that aluminum fluoride resembles an aluminum oxide as a glass-forming intermediate.

It may be interesting to note that the polymer, phosphonitrilic fluoride, $(PNF_2)_n$, forms a rubberlike vitreous substance, according to Schmitz-Dumont[33].

B. Chloride Glasses. $ZnCl_2$ forms a glass, according to Maier[23]. It is important that the substance be freshly prepared and contain no water. Morey[29] mentioned that $PbCl_2$ also forms a glass, and Mellor[26] noted that $RaCl_2$ forms a glassy mass. From the practical point of view, $ZnCl_2$ is probably the only glass-former among the chlorides. It is extremely hygroscopic. The writer has succeeded in compounding other chlorides with zinc chloride, indicating that zinc chloride is a good glass-former.

(*Continued on page* 580)

ANNUAL MEETING OF THE OPTICAL SOCIETY

Subjects Related to Glass and Mirrors

Several papers presented at the 31st meeting of the Optical Society of America, October 3-5, were of direct interest to glass technologists.

Highly resistive front surface aluminum mirrors were announced by N. W. Scott of the Engineering Board in Ft. Belvoir in his paper "A Simple Method for Producing Good Front Surface Mirrors". The aluminum mirror was protected by silicon monoxide partially oxidized to silica. The transition layer of silicon monoxide apparently serves by its equal compatibility with the metallic aluminum and the oxidic silica layers. The audience was assured that there would not be a rush on silicon oxide after the meeting since the layer was effectively provided by the evaporation at 1100°C. of a mixture of silica and silicon. The resulting film is unaffected by heating to 450°C. and to a one-half hour treatment with NaOH; its abrasion resistance by certain standard tests is a thousand times that of the uncoated mirror. What is more, the Chairman of the meeting, Dr. Harrison, was able to pass his handkerchief over the coated mirror without the slightest damage, a realistic treatment, according to him, which many recommended coatings do not stand.

Dealing with glass were two more publications. Doris L. Caballero, of Bell and Howell Company, in a report on "A Theoretical Development of Exact Solution of Reflectance of Multiple Layer Coatings" was able to perform a speedy calculation of double and multiple nonreflection films on glass with full consideration of multiple reflection. Harry B. Deuberry, of Bausch and Lomb, correlated the time of hardening safety goggles with the thickness of lenses in a simple manner valid for a limited practical area.

The coatings of purely metallic mirror faces were discussed by Dr. A. F. Turner of Bausch and Lomb in a paper "Increasing the Reflectance of Metals with Multiple Films". Reflectance can be increased from 91 to 98% on evaporated aluminum mirrors. Reflectance maxima are flat, comparing favorably with those of multiple layers on glass.

Optical Calculations

Among the many papers of value on geometrical optics were those which indirectly affect the optical glass industry by the proposition of new and faster methods of lens design.

Trends apparent at this meeting were threefold: (1) Emphasis of more modern equipment for calculation: tables, machines, electronic devices. (2) Increased mathematical armaments. (3) Appropriate selection by novel mathematical methods of certain of innumerous rays required to obtain precise image predetermination. (Herzberger)

Mr. M. Herzberger is scheduled to present new American concepts in this field to the first International Optical Convention in Paris on October 14. Mlle. G. Touvay, of the Paris Institute of Optics, who attended the New York meeting, has discussed the invitation extended to American Optical scientists.

Papers on various optical calculations and measurements were:

R. C. Jones, "Experimental Determination of the Matrix of a Crystalline Plate".

R. E. Hopkins and D. P. Feder, "Trigonometric Tables of Optical Calculations".

J. C. Evans and R. E. Hopkins, "Mathematical Table Projector Designed for Optical Calculations".

M. Herzberger, "Light Distribution in the Optical Image".

P. C. Foote and R. A. Woodson, "Lens Design and Tolerance Analysis Methods and Results".

R. E. Stephens, "Computation of Aspheric Surfaces for the Correction of Spherical Aberration". "The Design of Taylor Type Triplet Lenses".

J. G. Baker, "Apochromatic Photographic Lenses of Long Focal Length".

B. Goldberg and N. C. Benson, "Apparatus for Determining Spherical Aberration of Convex Surface of Paraboloid of Revolution".

S. Jacobsohn, S. Beloain and H. Hess, "A Rapid Non Destructive Method of Determining the Refractive Index of Lens Elements Using a Spectrometer".

M. G. Townsley and P. C. Foote, "Autocollimator for Precise Measurement of Flange Focal Distances".

G. W. Moffit, "Compensation of Flexure in Range Finders and Sighting Telescopes".

A. I. Mahan, "Further Studies of Focal Plane Anomalies in Roof Prisms".

New Phosphor Telescope

In the group of papers on geometrical optics which do not touch the field of optical glass at all, there were some of considerable general scientific significance.

The discussion of novel instruments based on phosphorescence started this spring in Cleveland by the sensational disclosure of devices "seeing" infra-red. This time, a new telescope-like instrument with selective brightness limitation permitting, for instance, to view the sky without interference by the excessive brightness of the solar disk was announced by the Institute of Optics, University of Rochester. The image is formed on a transparent phosphor screen. Two rotating disk shutters are inserted between objective and screen, and between screen and eyepiece so that the afterglow becomes visible during a limited period. The phosphor and the time period are selected in a way that the afterglow is proportional to exposure up to a certain brightness ("saturation") while any brightness beyond this range, e.g. that of the sun, does not increase the afterglow. The instrument was baptized Icaroscope commemorating Ikaros, son of Daidalos, who in the classic Greek myth first tried to approach the dazzling brightness of the sun. The reports on phosphorescence were:

Brian O'Brien, "A Brightness Limiting Phosphor Telescope with Selective Action on the Brighter Portions of an Image".

Gordon C. Milne, "Preparation of Phosphor Screens for the Icaroscope".

Donald Pearlman and Franz Urbach, "Saturation

(*Continued on page* 572)

THEORY AND PRACTICE OF GLASS-METAL SEALS

By J. A. MONACK
Engineering Consultant, Rutherford, N. J.

PART IV

Electrolysis in Seals

No attempt will be made here to discuss the accumulated knowledge[53] bearing on the subject of electrolysis in glass. Electrolysis is due to free ion conduction which obeys Faraday's Law. Observed behavior is ascribed to the univalent sodium and potassium ions and there is no evidence of the movement of divalent alkaline earth and lead ions through the glass.

Electrolysis is important not only because of energy loss in the electrical circuit but because continued electrolysis results eventually in tube failure either through leakage at the glass-metal interface or by cracking of the glass. The exact mechanism involved in electrolysis is not known. Sodium ions undoubtedly move to the negative wire, and the more negative the wire (e.g., grid lead as compared with filament lead) the more pronounced the effects in most cases. After the sodium ion reaches the cathode the subsequent reactions are not clear. It is commonly assumed that the sodium ion acquires an electron to become a sodium atom, that the sodium atom reacts with sorbed water to produce sodium hydroxide which in turn is electrolyzed.

Regardless of mechanism the result in the case of lead glass is a black dendritic deposit of lead along the wires (see Fig. 20) and leakage through the deposit from air to vacuum side of the seal. In a tungsten-Nonex seal the course of electrolysis is not quite so apparent. An investigation[54] of the effects of voltage and temperature on such seals brought out the following results. 1) The chances of failure by electrolysis are so small as to be negligible if the temperature of the glass does not exceed 250° C. and the voltage gradient does not exceed 400 volts per inch. 2) The temperature of the glass is far more important than the voltage gradient. 3) As the temperature increases, smaller and smaller voltage gradients are sufficient to cause failure. Thus, at 300° C. a gradient of 100 volts per inch will cause failure. 4) Failure occurred through cracks along the negative lead at 250° and 300° C.; generally by the same means at 350°, but occasionally by leakage along the positive lead; and at 400° the chances of failure by cracking or leaking were about equal. 5) Cracking at the negative lead was the result of progressively increasing strain caused by migration of positive ions, probably sodium, which altered the properties of the glass in the cathode zone. The increased stress was always in the direction of greater axial tension, indicating higher expansion of the glass. Leakage along the positive lead seemed to result from conversion of the oxide layer to tungsten trioxide by oxidation. 7) The oxide coating on the negative lead showed evidence of reduction to tungsten dioxide. 8) Heat alone at 400° caused deterioration of color but no leakage occurred. 9) The electrolytic changes in the glass, both with respect to strain (change in glass composition) and color (oxidation and reduction) were found to be reversible. Thus, reversal of current changed stress from tension to compression. A negative lead which had become dark in color became lighter on reversal of current; a positive lead, light in color, became darker on reversal.

Fig. 20. Dendritic lead deposits on wires as result of electrolysis in glass.

Glass-Metal Combinations

In order to avoid extended explanation each time reference is made to properties and behavior, discussion of specific glass-metal combinations has been deferred until all fundamentals were covered.

The thermal expansion curves of Figures 21 to 30 are based on data from many sources. No great difficulty was encountered in duplication of metal and alloy expansions. This, unfortunately, was not true in the case of glasses. Measurements by different laboratories on the thermal expansion of any one glass rarely agree, and the differences are often more than is desirable. An unsatisfactory state of affairs of this sort is the inevitable consequence of the use of glass samples from different melts, various types of equipment, failure to correct exactly for errors in measurement and calibration, different rates of heating and cooling, etc. In order, then, that the glass curves might be most representative

53. Littleton, J. T. and Morey, G. W., *The Electrical Properties of Glass*, John Wiley & Sons; New York, 1933.
54. Unpublished data by A. J. Monack and E. E. Beeton.

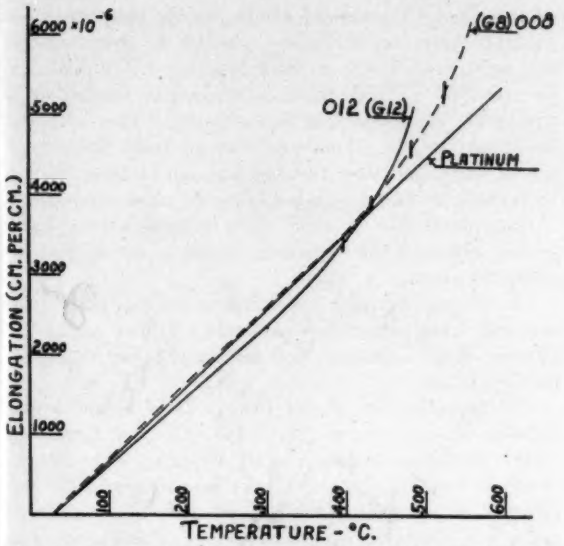


Fig. 21. Thermal expansion curves of platinum and two soft glasses.

the elongations used are the average of measurements by several laboratories in most cases. In some instances the curves are plotted from a single set of measurements.

Since the location of the strain point and annealing point is of some significance these are marked on the expansion curve for each glass by means of vertical lines. The upper or higher temperature line is the annealing point and the lower line is the strain point. The temperatures in Table 2 for these points represent the latest values; in some instances those on the expansion curves, being older values, may not agree exactly with the values in Table 2. The discrepancies, however, are not sufficient to be serious.

All of the glasses of Table 2 and Figures 21 to 30 are Corning glasses. The Corning Glass Works has for many years supplied nearly all glasses used in the lamp and tube industries or has developed the glasses made by other suppliers. The glasses of the tables and figures carry two designationts: (1) the number in parentheses is the Corning laboratory or development number, and (2) the other number is the Corning code number. The code number should be used whenever possible but the laboratory numbers are also given here because they have been used for many years and are familiar to many engineers.

No attempt will be made to discuss all possible glass-metal combinations here and in Table 7. Only commercially important seals are treated and, since much information on these has already been given, that which follows should be considered merely supplementary.

TABLE 7

GLASS-METAL-COMBINATIONS

1. Metals used with soft glasses	
a. Chrome iron	
Kind of metal:	28% chromium
Heat treatment:	H_2 (wet) or cracked gas firing to oxidize
Oxide layer:	Cr_2O_3
Kinds of glass:	024, 008, 8160, 001—internal seal; 012, any soft glass—external seal
Thermal expansions:	CrFe—108, glasses—89 to 96 x 10^{-7}
Types of seals:	Internal, external usually
Stresses:	Internal: axial and tangential compression, radial tension External: radial and tang. compression
b. Dumet	
Kind of metal:	Core: 42% Ni, 58% Fe; Cu sheath: 20-30% of total weight
Heat treatment:	None except heat to degas large diam.
Oxide layer:	Cu_2O (plus borax)
Kinds of glass:	012, 001, 008 (8160 risky)
Thermal expansions:	Dumet: radial—92, axial—65; glasses 89-92 x 10^{-7}
Type of seal:	Internal
Stresses:	Radial and axial tension, tangential compression
c. Cold-rolled steel	
Kind of metal:	SAE 1010; unplated, Ag, Ni, or Cu plated
Heat treatment:	Fired after plating
Oxide layer:	Fe_3O_4 plus Fe_2O_3 if unplated
Kinds of glass:	Internal seal: 1990, 1991 External seal: any soft glass
Thermal expansions:	Steel—130; 1990 and 1991—127; other soft glasses—89 to 96 x 10^{-7}
Types of seals:	Internal and external
Stresses:	Internal: none with proper anneal External: radial and tang. compression
d. Sylvania #4	
Kind of metal:	Ni 42%, Fe 52%, Cr 6%
Heat treatment:	Wet H_2 firing to oxidize
Oxide layer:	Cr_2O_3
Kinds of glass:	001, 012, 8160
Thermal expansions:	#4 alloy: 92; glasses: 89-92 x 10^{-7}
Type of seal:	Internal, other possible
Stresses:	None with proper anneal
e. Platinum	
Kind of metal:	Pure Pt or Pt-Ir alloy
Heat treatment:	None
Oxide layer:	Apparently none
Kinds of glass:	012, 001, 008, 8160
Thermal expansions:	Pt—90, glasses—89-92 x 10^{-7}
Types of seals:	Internal
Stresses:	Radial compression, axial and tangential tension
2. Metals used with hard glasses	
a. Tungsten	
Kind of metal:	Ground, polished
Heat treatment:	None
Oxide layer:	Before beading: W_2O_5 plus WO_3 After beading: mostly WO_2
Kinds of glass:	772, 707, 3320, 775, 705, 750, 704, 7991
Thermal expansions:	W—46, glasses—36 to 48 x 10^{-7}
Type of seal:	Internal
Stresses:	With 772, 3320, 775, radial compression to radial tension, axial and tang. tension to compression, depending upon anneal. With 707, 750, 705, 704, 7991, radial tension, axial and tang. compression
b. Molybdenum	
Kind of metal:	Ground, polished
Heat treatment:	None
Oxide layer:	Before beading: Mo_2O_5 plus MoO_3 After beading: mostly MoO_2
Kinds of glass:	704, 705, 706, 7052
Thermal expansions:	Mo—55, glasses—46 to 50 x 10^{-7}
Type of seal:	Internal
Stresses:	Radial compression, tangential and axial tension — approaching strain-free with proper anneal
c. Kovar	
Kind of metal:	Fe 54%, Ni 28%, Co 18%
Heat treatment:	900-1100° C. in H_2, 15 min. to 4 hrs.
Oxide layer:	CoO, NiO
Kinds of glass:	704, 705, 706, 7052
Thermal expansions:	Metal—50, glasses 46 to 50 x 10^{-7}
Types of seals:	Usually internal, external, tubular; occasionally others.
Stresses:	None with proper anneal
3. Metals used with soft and hard glasses	
a. Copper	
Kind of metal:	Oxygen-free, high conductivity (OFHC), or electrolytic
Heat treatment:	None
Oxide layer:	Cu_2O after sealing, plus some CuO before
Kinds of glass:	Theoretically, any glass
Thermal expansions:	Cu—160, glasses—33 to 96 x 10^{-7}
Types of seals:	Thin-edge tubular, ribbon, butt
Stresses:	Usually complex stress system

(1) *Dumet and Glass.* In Fig. 22 are shown the expansion of glasses 001, 008 and 012. Glass 008 is

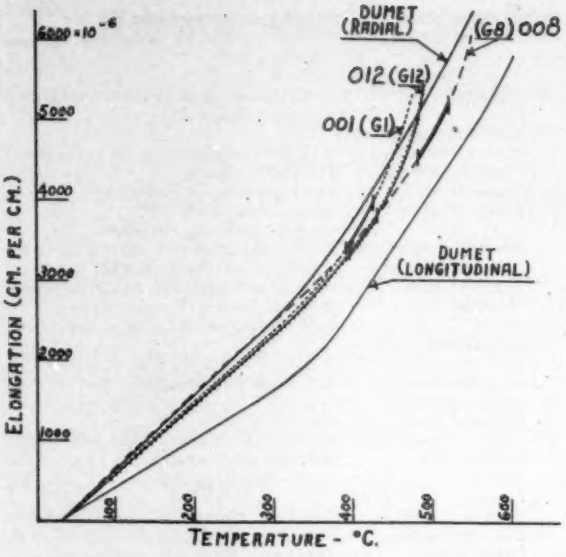


Fig. 22. Radial and longitudinal expansions of Dumet and expansions of three soft glasses.

normally supplied as bulbs, so that 001 and 012 are the commonly used sealing glasses with Dumet.

The difference between the radial and longitudinal elongations of Dumet at the annealing point of 012 glass is slightly over 1100 cm/cm. Since the radial elongation is not so far above the glass curve as to be troublesome, the longitudinal expansion is seen to be the source of nearly all failures due to cracking.

Long annealing at the strain point of a Dumet-012 seal is beneficial even though such annealing increases the radial and tangential stresses. The decrease in axial stress through such annealing more than compensates, however, in terms of gain.

Wire diameters of 0.020 in. or less offer few problems. Diameters up to 0.032 may be used with increasing difficulties.

(2) *Chrome Iron and Glass.* As Figures 23 and 24 make clear, the only glass which is a good match with 27-28% chromium-iron alloys (Sealmet 1, Carpenter "27") is 024. The curves cross at the annealing point

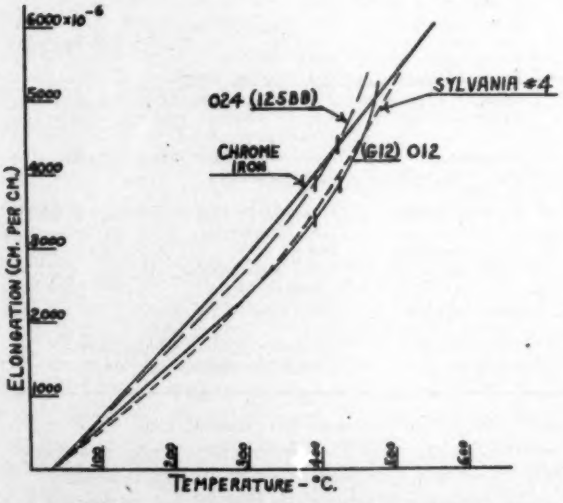


Fig. 23. Thermal expansion of 28% chrome iron and Sylvania #4 alloy and expansions of two matching glasses.

of the glass. The rate of cooling or the temperature of soaking, therefore, determines whether the stress at room temperature is tension or compression. Since operation at 100-300° C. will produce tangential tension it is preferable to anneal for compression. This will also counteract tension which would result from undue heating of the leads either through passage of large current or because of heat conducted from the tube elements.

Glass 8160 may be used where high resistivity is required, although the expansion match is not as good as with 024 glass.

The above analysis is applicable to internal seals. For external seals, since a considerably higher metal expansion is an advantage, it is advisable to use 012 glass for best results.

(3) *Sylvania No. 4 and Glass.* It is assumed that Sylvania No. 4, Driver-Harris No. 14, and Carpenter "426" are interchangeable in all respects. This alloy is lower in expansion than chrome iron. Figures 23 and 25 show an excellent match between these alloys and 012 glass, and since the expansion curves of 001 and 8160 are very close to 012, these also can be employed with good success. Seals made with the glasses mentioned are almost strain-free. The rate of cooling is not as important as in cases where the curves are less nearly parallel.

(4) *SAE 1010 Steel and Glass.* For use in internal seals glass 1990 is an excellent match with SAE 1010 steel. The glass curve crosses the steel curve just about midway between the annealing and strain points. Annealing is not critical nor are severe stresses set up in operation at any temperature. Because of the high expansion resistance to thermal shock is not as good as in the case of other glasses.

Corning glass 1991 (expansion curve not available) may also be used for internal seals.

SAE 1010 makes an excellent external seal with 001, 008, 012, 8160 and other glasses with expansion coefficients between 90 and 100 x 10^{-7}.

(5) *Tungsten and Glass.* Glass 772 is used more widely with tungsten than any other glass. As can be seen from Fig. 26, it is possible to obtain a seal with this combination which is relatively free of strain at room temperature. Rapid cooling produces tension, slow cooling compression. A stem showing excessive tension can be re-annealed to a strain-free or even a compression condition by holding at 500° C. for two to four hours, depending upon the amount of strain present, and then cooling.

In cooling from sealing temperature to room temperature the seal passes through a region of rather high radial tension in the neighborhood of 400° C., and considerable axial and tangential tension exists if the seal is operated at 200-300° C.

772 glass is subject to two disadvantages which sometimes cause difficulty. If overheated in the oxygen-hydrogen fires normally used for working, the glass has a tendency to decompose through volatilization of certain ingredients. Care must be exercised in heating. A second drawback, usually less serious, is the fact that this glass, if held for long periods of time at temperatures in the neighborhood of 625° C., tends to separate into two immiscible phases, thus producing milkiness when the glass is cooled to room temperature.

Glass 3320, yellowish in color because of uranium in

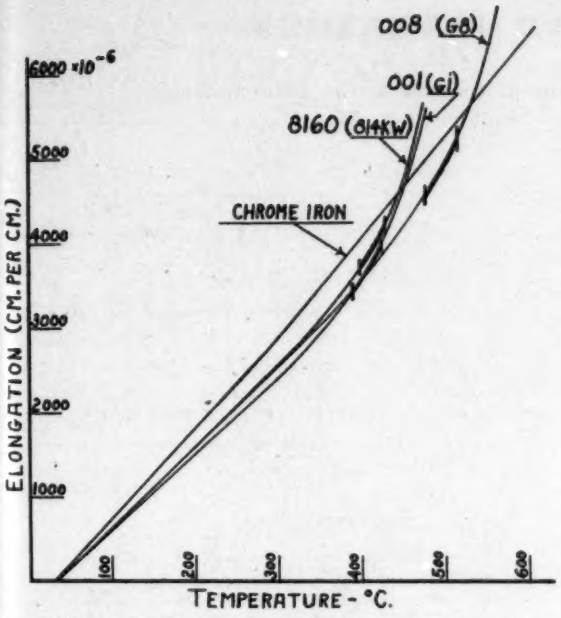


Fig. 24. Thermal expansion of 28% chrome iron and expansions of three soft glasses.

its composition, is sometimes used for beading leads which are sealed into 772 glass. While the expansion curves of tungsten and 3320 are a good match, no great advantage has been found in the use of this glass, and the color is often objectionable.

Glasses 707, 775, and 750 are sometimes sealed with tungsten but this is not very prevalent. The expansion relations are shown in Figure 27.

Glass 7991, a lead-free substitute for glass 772, has expansion characteristics (Figure 28) which are almost identical with those of glass 3320. The strain and annealing points are slightly higher than those of 3320 and 772.

On occasion it is desirable to seal a tungsten-772 assembly into Pyrex glass (code number 774). In order to do this an intermediate glass may be formed by powdering equal portions of 772 and 774 and melting them together to form a glass with expansion characteristics intermediate between those of the parent glasses. This new glass is used as part of a graded seal between the 772 and the 774.

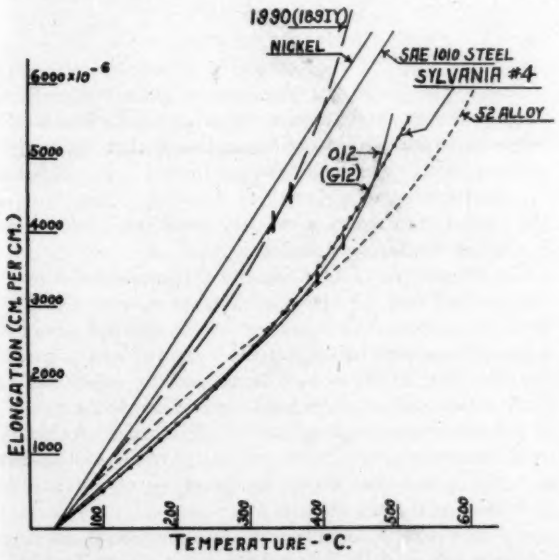


Fig. 25. Thermal expansion curves of glass 1990 with nickel and cold-rolled steel and glass 012 with Sylvania #4 alloy and Driver-Harris 52 Alloy.

(6) *Molybdenum and Glass.* Glasses 704, 705 and 706 have been used with molybdenum. Their expansion properties are very similar, as shown in Figure 28, and they may be interchanged without difficulty. A glass of better chemical stability is 7052, with an expansion curve very close to that of 706 but with slightly lower strain and annealing points.

In view of the relatively poor adherence of molybdenum oxide to the metal it is usually advisable to anneal when possible for radial compression.

(7) *Kovar and Glass.* Because of the close similarity in the shape of the expansion curves of this alloy and several of the sealing glasses there is usually no problem in making a choice. As Figure 29 shows, glasses 704, 705 and 706 are very good matches for internal and tubular seals, or the less common disc or edge seals. Glass 7052, not shown because it almost coincides with 706 in expansion, is probably the best choice because

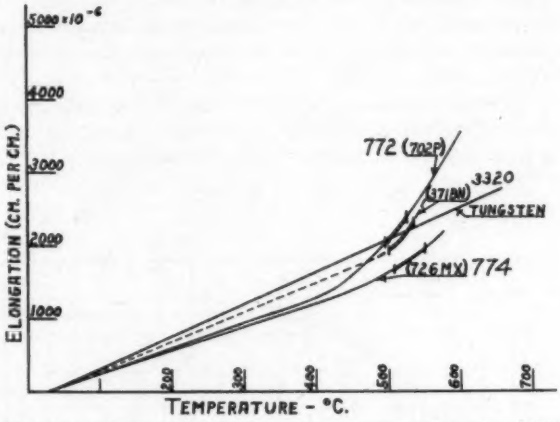


Fig. 26. Thermal expansions of tungsten with glass 772 (Nonex), glass 3320 ("uranium"), and glass 774 (Pyrex).

of its better chemical stability. Glass 703 is a good choice for an external seal with Kovar.

In making a Kovar-glass seal the metal is preferably pre-oxidized by rapid heating to 650° C. in a slightly oxidizing atmosphere. Excessive oxidation should be avoided. Batch oxidation in a furnace offers many advantages in uniformity. Heavy oxide gives mechanical strength with some danger of leaking, while a thin oxide results in a good gas-tight seal with some sacrifice of mechanical strength. The oxide film is apparently more soluble in 7052 glass than in 704 glass. A properly made seal with 704 glass is brownish-gray in appearance and a seal with 7052 glass has a silvery or mouse gray appearance.

Kovar is not feather edged but sharp edges and corners should be rounded to a radius of about half the thickness of the metal in order to avoid stress concentrations.

While the expansions of Kovar and its sealing glasses agree well, difficulty can be encountered because differential cooling of glass and metal may give the effect of con-

(*Continued on page* 576)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Glass Compositions

Patent No. 2,408,468 is on a borosilicate seal glass and it was assigned to General Electric Company by Kenneth C. Lyon of Millville, N. J.

This glass is useful as an intermediate seal for sealing a lead-wire of tungsten into an envelope of fused quartz and for joining quartz glass and "Pyrex". It is particularly useful in making a lead joint with a "Fernico" metal alloy cup brazed around the lead wire and having its thinned edge beaded with fused "Pyrex" glass, such as Corning "702EJ" and "774", which is sealed to the quartz envelope by a short intermediate length of this new glass.

This inventor has discovered that an improved glass for such purposes may be made by incorporating a small amount of lithia which may be as little as one quarter of one per cent. This produces a glass which is sufficiently conductive so that it may be melted by electricity. While lithia has been used previously, it has been in combination with soda or potash alkali in such large amounts that the coefficient of expansion was raised to an undesirable extent.

Two examples are given of this borosilicate glass which may be melted by passing an electric current through it after preheating until it becomes conductive.

Example 1, percentage by weight:

Silica (SiO_2)	83.25
Alumina (Al_2O_3)	4.5
Boric oxide (B_2O_3)	12
Lithia ($L_{i_2}O$)	¼

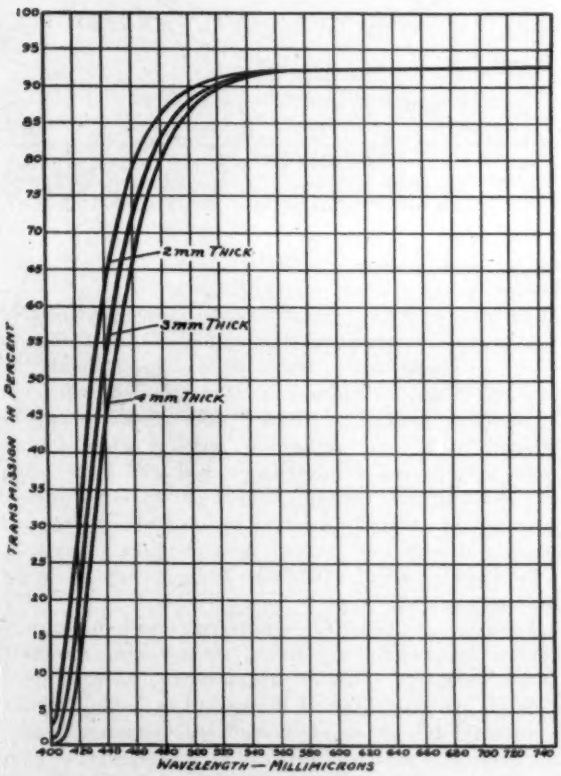


Fig. 1. Ultraviolet Absorbing Glass.

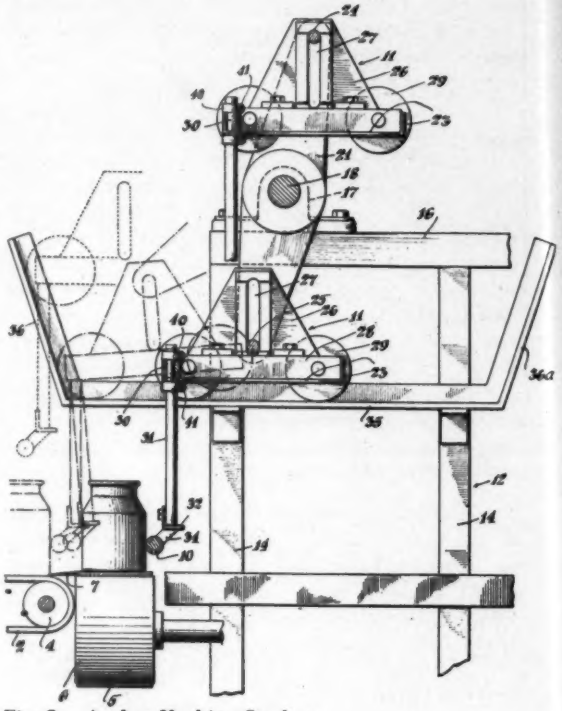


Fig. 2. Anchor Hocking Stacker.

Example 2:

Silica, powdered	78.23
Alumina	4.25
Boric oxide	16.96
Lithium carbonate ($L_{i_2}CO_3$)	.57

Patent No. 2,409,412 discloses a glass composition which will completely absorb ultraviolet radiations while transmitting all visible radiations longer than 405 millimicrons. This composition was invented by William H. Armistead and assigned to Corning Glass Works. The composition makes a yellow borosilicate glass which is colored by ferric chloride.

The inventor has found that the sharpness of the ultraviolet cut-off and the high visible transmission is largely dependent on the halide content of the finished product, a desirable content being preferably 0.6 per cent or more. Ten per cent Al_2O_3 is used to reduce the volatilization of the halide. The halides used are preferably the halides or halogen compounds of the alkali metals. A highly technical discussion is presented on the effect of different ingredients and the results produced by using varying quantities of them.

The following examples of glass compositions are given in per cent by weight, but it is stated that compositions 1, 4 and 5 are not within the scope of the invention.

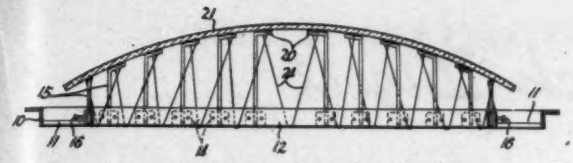


Fig. 3. Support for Sheet Glass while Bending.

Example	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
SiO_2	62.5	65.0	67.5	67.5	62.5	57.5	30.0	40.0	44.0	44.0
B_2O_3	15.0	15.0	15.0	25.0	25.0	25.0	35.0	20.0	20.0	20.0
Al_2O_3	10.0	10.0	10.0	...	5.0	10.0	20.0	20.0	20.0	20.0
Na_2O	12.5	10.0	7.5	7.5	7.5	7.5	...	...	6.0	6.0
K_2O	...	...	...	...	...	...	15.0	20.0	10.0	10.0
Fe_2O_3	.1	.1	.1	.05	.05	.05	.1	.25	.25	.10
Cl by analysis..	.56	.51	.59	.20	.29	.78	.66	.64	.83	1.38
Al_2O_3/R_2O	.8	1.0	1.33	...	.67	1.33	1.33	1.0	1.24	1.24
Percent R_2O added as halide.	3.0	3.0	3.0	4.0	4.0	4.0	4.0	5.0	5.0	5.0
Percent Na_2O added as Na_2SiF_6	3.0	3.0	3.0	...	...	...	...	...	6.0	6.0
	Dull amber, poor cutoff	Yellow, good cutoff	Bright yellow, good cutoff	No color, poor cutoff	No color, poor cutoff	Bright yellow, good cutoff	Bright yellow, good cutoff	Bright yellow, good cutoff	Bright yellow, good cutoff	Bright yellow, good cutoff

Figure 1 shows the percentage transmission of the composition given above in Example 10. It will be observed that this glass, 1mm. thick, completely absorbs the mercury line at 365 millimicrons.

Miscellaneous Processes

Patent No. 2,407,664 on a lehr stacker was assigned by the inventor, Gordon W. Herrold, to Anchor Hocking Glass Corporation.

The patent states that glassware as delivered from the forming machine has internal strains which must be removed. This is done by passing the ware through a lehr. The various devices heretofore employed for moving the ware from a conveyor to the lehr have not been satisfactory. This invention provides a stacker of the push bar type which is a great improvement over the prior art.

Figure 2 is a section through this improved stacker. A lehr conveyor 2 passes around a roller 4 and the ware is brought to this conveyor by a cross conveyor 5 which passes around pulleys 6. A push bar 10 is carried by a truck 11 which is actuated to push successive rows of ware onto the lehr conveyor 2. A support 12 is formed by angle irons 14, 15 and 16. Bearings 17, mounted on this support, carry a shaft 18 which has fixed thereto arms 21. The ends of these arms carry rods 24 and 25. Each of these rods actuate one of the trucks 11. Each truck is made up of a member 26 having a vertical slot 27 receiving one of the rods 24, 25. The members 26 carry rollers 29 and the members are connected by angle bars 23. The bar nearer to the lehr carries vertical rods 31 connected at their lower ends by an angle iron 32. These bars are vertically adjustable to accommodate ware of different heights. The push bar 10 is mounted on the angle iron 32 by brackets 34. Thus as the shaft 18 is rotated, the carriages 11 are urged in a circular path but a runway 35 engages the rollers 29 on the lower end of their travel and imparts a horizontal movement to each carriage 11. This is permitted by the vertical slots 27. Thus the ware is pushed in a straight line onto the lehr conveyor 2. At the end of this movement, the front rollers 23 engage an inclined member 36 which stops further horizontal movement and causes the carriage 11 to move upward into the position shown in dotted lines. This causes at first a rearward movement of the push bar 10 as indicated by the dotted lines. In this way, one of the push bars 10 shoves a row of ware onto the lehr conveyor while the other push bar moves into position to push another row of ware into the lehr.

Patent No. 2,408,526 is on a support for sheet glass while it is passing through a furnace, for example, such as in Pat. No. 2,021,180 to Galey. This patent was assigned to Pittsburgh Plate Glass Company by Gerald Z. Minton of Tarentum, Pa. In order to prevent marking of the glass during the bending operation, the glass engaging members are formed by a series of wires which are vertically adjustable to conform to the curvature of the glass.

Figure 3 is a vertical section through a metal frame 10 having rods 11 extending inwardly from its sides and ends where they support an inner frame 12. Spaced around this frame are straps 14 in which wires 15 are secured for vertical adjustment by set screws 16. The upper ends of the wires are bent as shown at 20 so as to support a sheet of glass of the desired curvature. In order to prevent contact between the glass and the supporting wires, an asbestos cord 24 is fixed to the inner frame 12 and passed around the bent ends 20 of the wires 15 and around the intermediate portions of the frame.

A modified form of the invention is shown in the patent in which the wires 15 are not only vertically adjustable as units, but also each wire includes a loop which may be bent to adjust the height of the upper end. The invention may be used to determine the shape to which a sheet is to be bent or it may be used to support a previously bent sheet during annealing.

Patent No. 2,408,599 is a device for transferring ware, such as tumblers, from a blowing machine to a burn-off machine and then from the burn-off machine to a conveyor. This is an invention of Edward H. Bennett who assigned it to Owens-Illinois Glass Company.

(*Continued on page* 570)

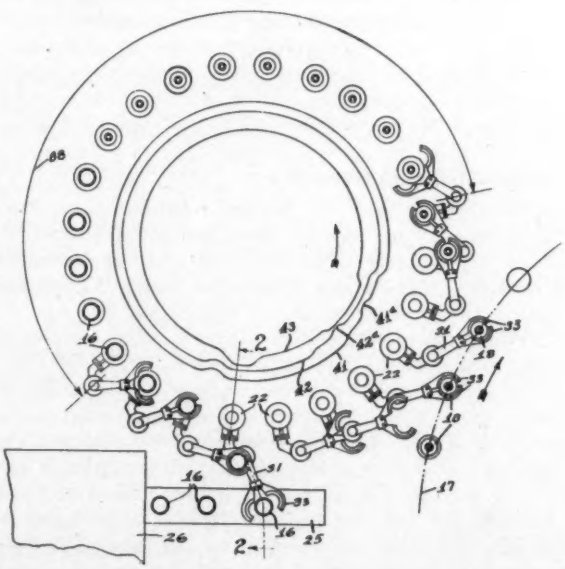


Fig. 4. Owens-Illinois Ware Transfer.

Research Digest

The Effect of Iron on Fluorescence in Glass

Due to the fact that the efficiency of luminescence in glass is less than that in crystals, little attention has been paid to the study of this phenomena in glasses. Most of the research has been toward the development of new and better crystalline phosphors. Efficient luminous glasses would be desirable for in many commercial applications they would facilitate manufacturing procedures. For example, the manufacture of modern fluorescent lamps would be greatly simplified by the use of fluorescent glass for the walls of the tube. Suitable fluorescent glasses could also find extensive application in X-ray radiography, electron microscopy and in modern cathode ray tubes. In addition, a study of the phenomenon in glasses might be used to obtain theoretical information regarding the structure and energy states existing in the vitreous state. With these points in mind, Thorington, Russell and Silverman (*Journal of the American Ceramic Society*, June 1946) have reported the results that they have obtained on the first of a series of systematic fundamental investigations dealing with the phenomenon of luminescence as it occurs in glass.

In this report, the mechanism of fluorescence as it occurs in a uranium glass when irradiated with ultraviolet light is discussed with special reference to factors affecting both the intensity and spectral distribution of the fluorescence. The destructive effect of iron on the fluorescence is discussed and illustrated by curves. Conclusions based on these data indicate that iron not only absorbs a large portion of the exciting radiation, thereby decreasing the fluorescence emission, but also re-emits this absorbed radiation in the infrared thus bringing about the infrared quenching of the fluorescence. Iron also causes an electrical disturbance around the fluorescing centers and is apparently capable of preventing the absorption of exciting radiation by these centers, further decreasing the intensity of fluorescence. A slight shift of the fluorescence spectrum toward shorter wave lengths is brought about by the presence of iron and is evidence of a weakening of the binding forces within the glass.

Optical Glass in Germany

Two reports by C. H. Hahner regarding the optical glass industry in Germany have recently been released. These reports may be ordered from the Department of Commerce, Office of the Publication Board, Washington 25, D. C. Brief summaries of each report follows.

Pots Used in Melting Optical Glass at Schott and Genossen. (Office of the Publication Board, Report PB 1843, 1945). The firm of Schott and Genossen produced almost all of the pots that they used in their optical glass manufacture. The methods used were conventional and the pots appeared to be of exceptionally good quality. It was stated that two to four melts of optical glass were made in each pot and that no difficulty was experienced in melting dense barium crown glasses in these pots. Pots were made by two methods: 1) slip casting into plaster of paris molds and 2) forming by hand. Only a small number of handmade pots were made for use in melting the high melting glasses of the zinc crown type.

The slip casting method used consisted of first blending the clay and grog mixture with a small amount of water and extruding the mixture in the form of 6 x 8 x 12 inch blocks. These blocks are then aged for about 30 days during which time they are kept moist but not "worked".

After the aging period, the clay is mixed with sufficient water and sodium silicate for casting. After casting, the pots are stored for an eight week period under controlled humidity and temperature, the humidity being from 70 to 80 per cent and the temperature 20°C. After this period, the pots are moved to a storage room where the temperature is kept at 80°C.

A tunnel kiln is used for the preliminary firing of the pot. The starting temperature being 200°C, the final temperature 700°C and the total time in the kiln from 3 to 4 days. The final firing of the pot is done in the glass melting furnace where the pots are heated to a temperature of 1430° to 1450°C in a period of 5 to 7 hours.

Production of Optical Glass in Germany and France (Office of the Publication Board, Report PB 1845, 1945). This report contains information on optical glass production at Schott and Genossen plants in Germany and at Parra-Mantois, Paris, France (during the occupation).

Schott produced some new types of optical glass having a relatively high index and a low dispersion which found use in serial camera lens. The closest approach to the Eastman Kodak glasses was Schott's glass SSK10 which contained 11.0 per cent of LaO_3 and 9.5 per cent of ThO_2.

Schott also had developed a new process of casting optical glass into slabs and then breaking and sawing the slabs into blocks. This process is cheaper and produces a greater quantity of large pieces of glass than the usual process of allowing the glass to cool in the pot. Nothing is known regarding the quality in respect to striae. A large number of prism blanks were prepared by this method of sawing from the glass block.

In addition to the fluoride coatings for optical elements, the Germans were using coatings of SiO_2 spun on the glass and coatings of SiO_2 and TiO_2 applied by the Schott process. The Schott process coating can be adjusted so as to be used on glasses of different indices of refraction and is the most resistant to abrasion of any used.

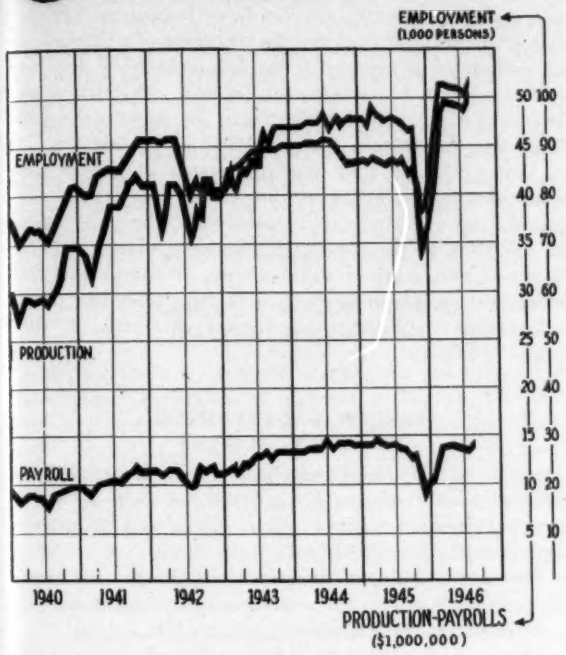
At Zeiss, the glass was obtained in the form of rectangular slabs weighing from one to ten or more pounds. These were cut by saws into sheets 3/8 to about 1¼ inches thick. The sheets were then marked off into squares with a glass cutter and broken off at the marks by the means of a small press.

After preparing the glass piece, they were placed on the hearth of a furnace until soft and then pressed in a steel mold to shape. Three types of furnace were used

(*Continued on page* 566)

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



Activity in the glass industry during the month of August 1946 jumped about 7 per cent, according to the Production Index. The figure reported for the month was $51,500,000. July production had been an estimated $48,000,000. During August 1945, the Production Index reported that activity had reached an approximate $45,300,000. This is about 13 per cent under production for August 1946. The estimated total production thus far in 1946 is $383,500,000, as compared with $377,300,000 during the same period in 1945.

Employment and payrolls: Employment during the month of August rose slightly, from the 100,000 persons employed during July, to 104,000. During August 1945, employment was reported at 87,200—about 19 per cent below August this year.

Payrolls during August also rose to an estimated $14,000,000. This figure represents an increase of about 7 per cent over the $13,000,000 reported for July. Payrolls during August 1945 were $12,300,000—a difference of about 13 per cent. During the January-August 1946 period, glass manufacturers have paid out about $94,000,000, as compared with $108,000,000 during the corresponding period in 1945.

Glass container production and shipments dropped off slightly for the month of September after reaching an all-time high for August. Based on figures released by the Bureau of Census, production for the month of September was 9,814,496 gross. This represents an approximate 7 per cent decrease from the 10,658,710 gross reported for August. Production during September 1945 was about 9 per cent below September this year, or 8,991,084 gross. Total glass production at the end of the three-quarter period of 1946 is 86,262,711 gross. At the close of the corresponding period in 1945, production had reached a total of 78,014,444 gross.

Shipments of glass containers for September were 9,777,660 gross, which is about 8 per cent below the 10,650,866 gross shipped during August. During September 1945, shipments were 8,949,888 gross, which is about 8 per cent below September this year. Shipments made during the first nine months of 1946 are 86,249,309 gross in comparison with 79,600,184 gross shipped during that period in 1945.

Stocks on hand at the end of September are 3,942,188 gross, as compared with 3,924,890 gross at the close of August and 3,816,619 gross at the close of September 1945.

Plate glass production rose about 25 per cent to 21,142,287 sq. ft. for the month of September 1946,

(*Continued on page* 566)

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production September 1946	*Stocks September* 1946
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	3,515,198	1,925,791
	Wide Mouth	3,251,846	1,014,613
Dairy Products		339,478	153,902
Beverages, Returnable		609,065	345,147
Beverages, Non-returnable		.....	.....
Beer, Returnable		442,992	81,200
Beer, Non-returnable		49,690	17,041
Liquors		884,552	165,306
Wines		388,411	66,663
Packers' Tumblers, Home Canning		333,264	172,525
Total		9,814,496	3,942,188

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	September 1946
Narrow Neck Containers	
Foods	1,309,173
Medicinal & Health Supplies	1,136,430
Chemical, Household, Industrials	484,029
Beverages, Returnable	528,965
Beverages, Non-returnable	.....
Beer, Returnable	411,317
Beer, Non-returnable	48,298
Liquors	846,528
Wines	369,779
Toiletries & Cosmetics	571,912
Sub-Total (Narrow)	5,706,431
Wide Mouth Containers	
Foods	2,806,440
Dairy Products	314,355
Medicinal & Health Supplies	235,845
Chemical, Household, Industrials	97,614
Toiletries & Cosmetics	106,334
Packers' Tumblers, Home Canning	365,979
Sub-Total (Wide)	3,926,567
Total Domestic	9,632,998
Export Shipments	144,662
Total Shipments	9,777,660

PROFESSOR TURNER ACCEPTS POST AT UNIVERSITY OF ILLINOIS

Dr. W. E. S. Turner, Professor Emeritus at the University of Sheffield, England, has accepted an appointment as Visiting Professor of Glass Technology in the Department of Ceramic Engineering at the University of Illinois. In addition to presenting a special seminar in Glass Technology, Dr. Turner will assist and advise in the expanded educational and research program in glass technology.

From 1904 to 1914, he was in charge of teaching and research in Physical Chemistry at the University of Sheffield, and in 1915, he created a Department of Glass Technology which he headed and from which he recently retired.

In 1916, the Society of Glass Technology was founded and he twice served as President of that Society. He was Honorary General Secretary from 1916-1946, and has been from the outset, and still remains, Editor of the Society's Journal and other publications.

NEW BLAST-CLEANING DEVICE

The Vacu-Blast Company, 1054 Broadway, Burlingame, California, now has in production a new blast-cleaning device for cleaning or refinishing metal, concrete or other hard surfaces.

Named the "Vacu-Blaster", a unique feature of the device is its vacuum return system, which permits no abrasives or other particles to escape into the open. It may be used without special precautions or preparations and requires no masks, goggles or protective clothing. The vacuum pick-up system, according to the announcement, is so positive in action that precision machinery, food products or other objects of value need not be removed, or even covered, although they be adjacent to an operating Vacu-Blaster.

Operation of a Vacu-Blaster is predominantly automatic. The blast is controlled by a switch at the gun through which the abrasive blast is directed and through which grit and dust are picked up. The vacuum system operates continuously, returning grit and refuse to the reclaiming tank where reusable grit is returned to the blasting system while dust and refuse are shunted off to a dust collector.

Reclaimed abrasive is automatically dumped into the grit-supply tank at the close of each operating cycle. At the same time, the blasting assembly is automatically flushed with clean air to prevent possible clogging. Loading of fresh abrasive into the Vacu-Blaster is easily accomplished by the vacuum system which picks up the grit through the blasting gun from a container on the floor.

HERBERT ABRAHAMSON NAMED VICE PRESIDENT—SALES

The Neville Island Glass Company has announced the appointment of Herbert Abrahamson as Vice President in charge of Sales.

Serving the glass manufacturing industry for 20 years, Mr. Abrahamson was formerly New York representative for the Brockway Glass Company, New England Sales Manager of Olean Glass Company and New York City representative of the Thatcher Manufacturing Company.

Mr. Abrahamson's new headquarters will be at the main office of the company on Neville Island, Pa.

BOOK REVIEW

Scientific Instruments
By Herbert J. Cooper, Editor

The ground covered by this volume is very broad, comprising optical instruments, measuring instruments, navigational and surveying instruments, liquid testing, acoustics, calculating machines, hardness indicators, vacuum tubes. Because of its scope the treatment of each method or instrument is necessarily brief, but the book is a useful acquisition for reference purposes. The line drawings and diagrams, of which there are many, are excellent; the photographs leave much to be desired.

Although there is a brief discussion of glasses and their optical properties in connection with lenses, eyepieces, and objectives of various sorts, the chief value of the book to the glass technologist is almost entirely as a reference work on various types of instruments and measurements which he may use in laboratory and plant.

Chemical Publishing Co., Inc., N. Y., 1946. vi 305 pages. $6.00.

A. J. M.

EISLER ENGINEERING TO MAKE SURVEY

A survey of electronic and electric lamp manufacturing equipment shortages in Europe and the Near East has been inaugurated by the Eisler Engineering Company as a preparation for retooling factories there.

The survey will include a study of the present needs of foreign industry for replacement of machines destroyed during the war.

Charles Eisler, head of the firm, has also announced an intensive expansion program to meet national and international needs. Improved production equipment will be added to plant facilities shortly. The Transformer Division has already expanded its testing facilities into a Test Department with a custom built test panel.

NEW EDITION OF CONSULTANT DIRECTORY

The Association of Consulting Chemists and Chemical Engineers, Inc., 50 East 41st Street, New York 17, New York, has announced the publication of its Tenth Edition of the Classified Directory. The Directory is available without charge to applicants giving full name, business connection and address and source of reference.

The Directory is divided into three sections: Key Sheet, Scope Sheets and Index. The Key Sheet is a record of the various services performed by the Association members; Scope Sheets are one-page statements from each member, descriptive of his and his organization's qualifications, scope, functions and activities; and the Index provides, in alphabetical order, membership list and company affiliations of members and geographical location of members and their firms.

BALL BROTHERS' RETIRED SUPERINTENDENT DIES

Fred E. Jewett, retired General Superintendent of Ball Brothers Company, died at the age of 72.

Mr. Jewett retired six years ago after serving 48 years with the company. He had been General Superintendent since 1902. Surviving are his widow, a son, George, and two daughters.

PATENTS MADE AVAILABLE TO PUBLIC

A total of 181 patents covering the broad field of the manufacture and use of glass fiber products has been made available to the public for non-exclusive licensing, it has been announced recently by the Patent Office, Department of Commerce. The patents, owned by the Owens-Corning Fiberglas Corporation, have been listed on the Register of Patents Available for Licensing or Sale.

Included among the glass fiber patents are inventions relating to glass textile yarns and fabrics, glass fiber packs and glass fiber insulation. In addition there are 24 patents owned by the Corporation covering the inventions for the use of glass fibers or glass fiber products in various types of manufactured articles.

AMERICAN POTASH ELECTS BOARD CHAIRMAN

American Potash & Chemical Corporation has announced the election of Bernard R. Armour as Chairman of the Board. The new chairman is president of Heyden Chemical Corporation and succeeds W. J. Froelich, resigned.

At the same time, it was announced that Dr. Donald B. Keyes, Vice President of the Heyden Company, and William S. Glazier, a partner of Lehman Brothers, were elected to the Board. Dr. Keyes and Robert Brown were elected to the company's executive committee.

BRANCH SUPERINTENDENT NAMED BY PITTSBURGH PLATE

The appointment of Phillip E. Sharr as Superintendent of the Pittsburgh Plate Glass Company's alkali-producing plant at Bartlett, California, was recently announced by the company.

Mr. Sharr has been associated with the Columbia Chemical Division for the past nine years and has been chief engineer at the California plant for the past year. Prior to his assignment to the Bartlett plant, he was in charge of the planning department at the Barberton, Ohio plant.

The Bartlett plant, currently producing soda ash and sodium sesquicarbonate, was acquired by the company from the Pacific Alkali Company in 1945.

MOBILE OPTICAL UNIT HAS B & L EQUIPMENT

America's first mobile clinic for providing eye care in remote areas was recently dedicated in New Jersey, and is sponsored by the New Jersey Commission for the Blind. The Commission has pioneered in bringing eye care to the needy in sparsely settled areas of the state.

The unit, which is nineteen feet long and more than six feet wide, contains equipment furnished by the Bausch & Lomb Optical Company. This equipment includes a refracting chair, refractor, slit lamp, and such diagnostic equipment as retinoscopes and ophthalmoscopes are found in the unit's modern eye examining room.

Bausch & Lomb planned the interior layout so that the many delicate instruments used in eye examinations could be safely transported to rural areas for immediate clinical diagnosis of eye conditions.

DR. FAY TOOLEY JOINS UNIVERSITY OF ILLINOIS

It has recently been announced that Dr. Fay Va Nisle Tooley has joined the staff of the Department of Ceramic Engineering at the University of Illinois as Professor of Glass Technology. He will organize and direct a new and expanded program of instruction and research in Ceramic Engineering.

During the period of his undergraduate work at the University of Illinois, Dr. Tooley was employed in part-time work as a chemical analyst in the Laboratory of Applied Chemistry, the Department of Mining Engineering and the Illinois State Water Survey. He received the A.B. degree in Chemistry in 1932.

From 1932 to 1938, Dr. Tooley was a full-time member of the staff of the Illinois State Geological Survey and was also doing graduate work in ceramics. He obtained the M.S. degree in Ceramics in 1936, presenting a thesis on studies in glass composition.

He received the Ph.D. in Ceramic Engineering in 1939, after which he joined the staff of the Owens-Corning Fiberglas Corporation as head of the Research Department at their laboratory and plant at Newark, Ohio. In this capacity he has directed the activities of a staff of forty-two people working on glass research, development and control. He has been concerned with and engaged in the development of fiberglas from its inception through the laboratory and pilot plant studies to full-scale production.

FIBERGLAS APPOINTS PLANT MANAGER

Harper Donnald has been appointed Manager of the new Owens-Corning Fiberglas Corporation plant now under construction at Kansas City, Kansas, according to a recent announcement.

Mr. Donnald has served as Production Manager of the Newark, Ohio, Fiberglas plant since January 1, 1946. He has been with the Fiberglas Corporation since 1940.

Production at the Kansas City plant is scheduled to start in November and operations will be steadily accelerated until the plant is in full operation.

RUSSELL RICE HEADS GLASS COMPANIES

The directors of Fourco Glass Company, Rolland Glass Company, Adamston Flat Glass Company and Harding Glass Company have elected Russell Rice to succeed the late Eugene Rolland as President of these companies.

Mr. Rice joined the Adamston Flat Glass Company in 1926 as his first venture in the glass business. In 1929, he joined the Rolland Glass Company working through several departments of the plant to become Assistant Superintendent.

Mr. Rice was appointed Assistant to President, Eugene Rolland, in 1944. He remained in that position until the death of A. J. Rolland when he was elected to the offices which Mr. Rolland held.

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CURRENT STATISTICS . . .
(*Continued from page* 563)

according to the Hughes Statistical Bureau. Production during August was 16,802,955 sq. ft. and during September 1945, it was 10,353,520 sq. ft. Total plate glass production at the close of the third quarter of 1946 was 147,543,875 sq. ft. as compared with 76,281,143 sq. ft. produced during the corresponding period in 1945.

Automatic tumbler production for the month of September 1946 dropped off about 15 per cent to 6,710,-674 dozens. During August, production had been 7,891,-004 dozens and during September 1945, it was 5,825,760 dozens. Shipments also fell off for the month and were reported to be 6,077,694 dozens, which is about 23 per cent under the figure for August which was 7,946,335 dozens. September 1945 shipments were 5,785,628 dozens. Stocks on hand at the close of September were 5,352,309 dozens, as compared with 4,784,048 dozens at the close of August. Stocks at the end of September 1945 were 4,550,740 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table kitchen and household glassware for September 1946 dropped about 16 per cent to 3,645,278 dozens. During August, sales were 4,334,632 dozens and during September 1945, they were 2,867,253 dozens. At the close of the 12-month period ending September 1946, manufacturers' sales had reached a total of 45,504,474 dozens.

RESEARCH DIGEST . . .
(*Continued from page* 562)

for this work; a stationary hearth furnace, a furnace with a rotating hearth and a furnace where the glass is placed on small refractory slabs that are carried through a small heated tunnel.

At Parra-Mantois borosilicate type glass was made in covered pots in addition to dense barium crown. The borosilicate glass was of very good color but some of the dense barium crown glass being made was very seedy and had a bad color.

Small pressings were annealed in a vertical furnace in which the glass and sand are fed in the top of the furnace and removed from the bottom. There is a temperature gradient from the top to the bottom of the furnace.

Note: The price of the publications is as follows: Photostat, $1.00 each; microfilm, 50¢ each.

RICHARD BASTIAN JOINS GLASS FIBERS, INC.

R. H. Barnard, President of Glass Fibers, Inc., has announced that Richard R. Bastian has joined the staff of the recently organized firm.

Mr. Bastian recently resigned as General Purchasing Agent of Owens-Corning Fiberglas Corporation. He had previously served the Fiberglas company as a chemist and as purchasing agent with headquarters in Newark. He was one of the original group from Corning Glass Works that joined the Fiberglas company upon its formation in 1938. At Corning, Mr. Bastian had been active in the fiber products division from its inception in 1935.

NORTHERN OHIO SECTION HOST TO PROF. TURNER

Honor was paid to Dr. William Ernest Stephen Turner, emeritus professor of Sheffield University, England, eminent glass technologist and founder and president of the International Glass Commission, in a week-long series of plant visits, luncheons and seminar sessions in this important center in the glass industry. Dr. Turner came to Toledo primarily to be guest at the dinner meeting of the Northwestern Ohio section of the American Ceramic Society in the Commodore Perry hotel on October 8. Dr. H. H. Holscher, chairman of the section, presided.

In his address on "Recent Developments on Tank Melting Furnaces," Dr. Turner limited the scope of his discussion to two chief points—studies which sought to show the temperature distribution in the glass furnace, and some suggestions as to how to get the heat to specific locations in the mass of glass so as to melt more efficiently.

"In these days when the glass manufacturer is being squeezed by high labor costs on the one hand and ceiling prices on the other there is no subject of greater importance than economies in melting the glass," declared the professor.

He described work done at Sheffield University in a small tank furnace in his laboratory covering nearly nine years. Important results as to the amount of gas per minute to maintain 1400-degree Centigrade temperature were cited as a definite result of this study. He cited a gas consumption of 12 cubic feet per minute for lime-soda-silica glass, as against 9.5 cubic feet for green glass, 10 cubic feet for lead-crystal, 14 to 15 cubic feet for pyrex and less than 12 cubic feet for cobalt glasses.

He showed several graphs giving a relationship between the results obtained with the small laboratory furnace and larger furnaces. Dr. Turner said most of the data on studies made in larger furnaces had come from Owens-Illinois Glass Co., and he warmly praised the "progressive and open policy of Owens-Illinois in making available to glass technologists" its findings in fundamental research.

It was Dr. Turner's opinion that it would be a long time before electricity could compete with coal or gas in Britain or the United States. However, he said the studies being made may point to some advantages in rapid melting in small chambers where gas and electricity may both be used to provide temperature control of both the surface and the body of the glass. He said all glass technologists will have to pay attention in the future to the possibilities of electric melting.

Urban E. Bowes, executive director of research for Owens-Illinois, on behalf of the Northwestern Ohio section, presented Dr. Turner with an illuminated scroll testimonial to this devotion and contributions to glass technology.

He asked permission at that meeting to present to Dr. Ross C. Purdy, secretary general emeritus of the American Ceramic Society, an illuminated address from his fellow glass technologists in England.

Wilbur F. Brown, of Libbey-Owens-Ford Glass Co., long-time friend of Dr. Turner, who was chairman of a visitation committee, arranged a complete schedule for the Turners while in Toledo.

D. H. Goodwillie, executive vice president of Libbey-Owens-Ford, presented the plaque. He recounted how the Rossford plant produced only quarter-inch plate glass 30 years ago before the days of the chemists, engineers, and glass technologists. He stressed the fine friendship which had existed between the European and American glassmakers for many years.

Dr. Turner told the technical men at the luncheon that the LOF Technical Building must be a good investment for it is growing.

The general reception committee for Dr. and Mrs. Turner included Don E. Sharp, of Libbey-Owens-Ford; J. H. Waggoner, of Owens-Corning Fiberglas, and U. E. Bowes, of Owens-Illinois.

A. H. Couch, ceramics development engineer for Libbey-Owens-Ford, was chairman of the arrangements and ticket committee, and V. W. Boeker, Owens-Corning, headed the information committee.

Chairman Brown of the visitation committee had working with him Mr. Couch, Blake-More Godwin, director of the Toledo Museum of Art; John Pearse, Libbey-Owens-Ford; Mr. Bowes, Owens-Illinois; F. G. Schwalbe, Toledo Engineering Co.; H. C. Weller, Surface Combustion Corp., and Dr. H. R. Black, of Libbey Glass. Section officers include T. Carter Vaughan, Libbey-Owens-Ford, secretary, and J. Fred Chambers, National Gypsum Co., Luckey, Ohio, treasurer.

PENNSALT TRANSFERS SALES MANAGERS

The Pennsylvania Salt Manufacturing Company has announced the transfer of Louis M. Kuilema, formerly District Sales Manager at the Cincinnati office, to the Wisconsin territory. Mr. Kuilema will be located as District Sales Manager of this territory at 20 N. Wacker Drive, Chicago, Ill.

At the same time, it was announced that Charles W. Dermitt has been moved to Cincinnati as Mr. Kuilema's successor after four years as assistant to the Pittsburgh District Sales Manager.

PITTSBURGH SECTION FALL MEETING

The Pittsburgh Section of the American Ceramic Society held its first technical meeting of the fall season at Mellon Institute on October 7.

Dr. Frank W. Preston presented an account of his trip to Bikini last July to observe the second atom bomb test. He gave many interesting sidelights on the preparations for the test, the people present and the geology and natural history of Kwajalein and Bikini atolls. Dr. Preston made the trip as The Glass Industry's technical representative.

E. A. TICE JOINS INTERNATIONAL NICKEL

According to a recent announcement, E. A. Tice has joined the Corrosion Engineering Section of the Development and Research Division of the International Nickel Company, Inc., as Corrosion Engineer.

Mr. Tice was formerly associated with Bethlehem Steel Company's Research Department. He is a member of the American Society for Testing Materials, the National Association of Corrosion Engineers and the Electro-Chemical Society.

NEW EQUIPMENT AND SUPPLIES

PIRANI TUBES

Sylvania Electric Products, Inc., Electronic Division, 500 Fifth Avenue, New York 18, New York, has made available Pirani tubes suitable for pressure gages and leak detectors in evacuating apparatus and automatic pressure equipment.

The tubes are designed with special tungsten filaments having a high temperature coefficient of resistance permitting direct readings of gas pressures. Change in gas pressure produces a change in thermal conductivity, filament temperature and filament resistance. Measurement of filament resistance, calibrated in terms of pressures for individual gases, is indicated on an 0-1 milliammeter placed in a simple bridge circuit.

Matched pairs of Pirani tubes are recommended for greater accuracy. One tube is sealed directly into the evacuating system while the second or compensating tube is left intact, opened to surrounding air or filled with a specific gas to a standard pressure. Tubes are usually mounted in close proximity to provide the same ambient and the installation is usually carefully shielded from radiant heat or air currents.

Readings may be obtained with ± 5% accuracy within a pressure range of one to one thousand microns. The tubes are supplied in nonex glass envelopes with tubulation for direct sealing into apparatus. Overall length of the tube is approximately eight inches. They are designed to operate at 1.5 volts, 100 milliamperes. Cold resistance of the filament is 6.6 ohms. Hot resistance at 100 milliamperes in evacuated tube ranges from 15.5 to 17.0 ohms.

METHYL-PURPLE INDICATOR INTRODUCED

Fleisher Chemical Company, P. O. Box 616, Benjamin Franklin Station, Washington 4, D. C., has announced a new indicator, Methyl-Purple Indicator, intended to replace the standard, methyl orange, in alkalinity titrations.

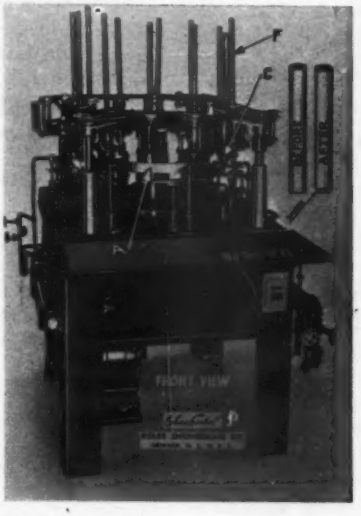
In alkaline solution, the new indicator exhibits an emerald green color; in an acid solution, a purple color. An intermediate steel gray tint provides a convenient warning of the approaching endpoint. According to the announcement, the color changes are sharp and distinct and of such contrast as to make their perception definite and indisputable.

Color transitions take place over a narrow pH differential and, when approaching the endpoint of a carbonate titration, a single drop of 0.05N acid effects a transition from the alkaline green to the warning gray, while another drop produces the purple endpoint.

FLUORESCENT TUBE END FORMING MACHINE

The Eisler Engineering Company, Newark, New Jersey, has announced the marketing of a new machine, Model "FL", for shaping the ends of fluorescent tubes.

The essential parts of the machine



are 12 chucks (C in the illustration) and a barrel cam which moves the chucks from station to station at intervals. A track (A in the illustration) on which the chucks ride automatically opens and closes the chuck jaws. The machine shapes only one end of the glass tube at a time so that the operator has to invert the tubes after the one end is finished and insert them back into the machine. The operator's job consists of only inserting the glass tubes into the machine, inverting them when necessary and removing them when both ends are shaped.

The machine, powered by a ½ HP motor, is fully automatic. Fuels for heating the glass tubes are gas, air and oxygen. Production of the machine is from 700 to 900 tubes an hour depending on the size of glass tubes used. Sizes of tubes that the chucks can hold are from 1" to 2⅛" O.D.

MECHANICAL PRESSURE GAUGE

W. C. Dillon & Company, Inc., 5410 West Harrison Street, Chicago 44, Illinois, has announced a new Dillon mechanical pressure gauge for use in accurate testing work.

The new pressure gauge is compact in size: The 0-100 pound model measures 3⅝" long x 2-7/32" high x 1¾" wide. It weighs only 1¼ lbs. net. The 0-250, 0-500, 0-1000 pound models all measure 4-15/16" long x 2-7/16" high x 2-5/16" wide. They weigh only 2 lbs. net. The 0-2500 and 0-5000 pound models measure 4⅝" long x 2⅜" high x 2¾" wide and weigh 2 1.2 lbs. net. All models are furnished with a wooden carrying case.

The gauge can be used to check pressure between spot welding machine electrodes, pressure between platens in all types of presses, pressure between moving rollers, tension in a moving thread, twine, wire, etc. It has been designed small so that it can fit into tight spots heretofore inaccessible yet where pressures of static or moving parts must be measured. It works in vises, between all types of clamps and can be converted into a miniature testing machine.

The gauge is almost entirely unaffected by extreme temperature changes and can be used indoors or out. In cases where the operator cannot get close enough to read the dial, remote repeater stations that work up to 500 feet and more can be obtained.

CATALOGUES RECEIVED

Cambridge Wire Cloth Company, Cambridge, Maryland, has published a catalogue featuring Cambridge conveyor belts.

The 140-page, two-color catalogue consists of eight sections which are headed, "Cambridge Belt Applications", "Cambridge Belt Constructions", "Choice of Material (Metals and Alloys)", "Cambridge Belt Specifications", "Cambridge High Temperature Belts (Lehr and Industrial Furnace Belts)", "Conveyor Design", "Installation and Operation" and the final section, "Tables, Questionnaires, etc."

Automatic Temperature Control Co., Inc., 34 East Logan Street, Philadelphia 44, Pa., has issued a bulletin featuring their time switches.

Designated "Bulletin T-55", the booklet illustrates five types of switches for the volume user. Each type of switch is pictured and a small diagram of operation is shown. Descriptive material for each includes speeds and particular applications.

O. Zernickow Company, 15 Park Row, New York 7, has published a circular featuring the O-Z Improved Hand Tachometers, a new line which the company has placed on the market.

The circular illustrates the tachometer and lists advantages and specifications. Carrying case and accessories are also shown.

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RESISTS SULFIDES

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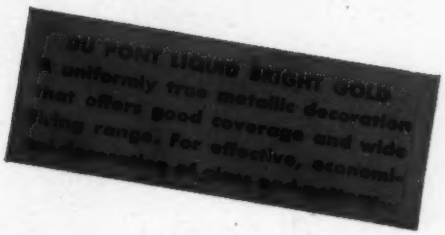

Let Du Pont be your single source not only for colors of all types, but also for overglazes and underglazes, body slip and glaze stains and Squeegee Oil. Du Pont Technical Service Men and Laboratories are ready to help you with your problems. Trial runs can be made on your ware, in your plant or in our laboratories. Learn more about these colors! Just write: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

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Smith Glass Batch Mixer in discharge position. Fast "Tilt and Pour" discharge.

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Glass Batch
MIXERS

INVENTIONS & INVENTORS . . .
(*Continued from page* 561)

The patent is directed primarily to the mechanical construction of a transfer mechanism which might be employed to transfer articles to and from any type of rotary machine. The diagram shown in Fig. 4 gives a general idea of machines where the invention might be used but does not show details of construction which can be obtained from the five sheets of drawings in the patent.

The line 17 indicates the path of travel of a series of blowing spindles 18 in which tumblers 16 are formed. The associated burn-off machine carries a series of transfer arms 31 which work, two at a time, to pick up a pair

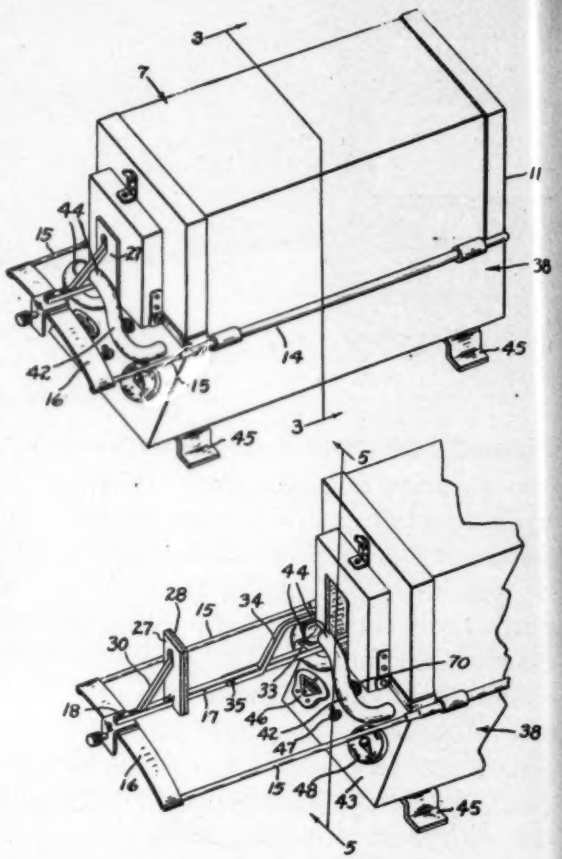


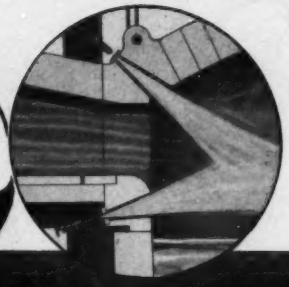
Fig. 5. Device for Hardening Lenses.

of tumblers in cups 33. These cups are then lifted by cams 41 and 42 and swing inwardly by a cam 43. This brings the tumblers over holders 22 on the burn-off machine which carry the ware during the burn-off operation after which the arms 31 swing outwardly, lower, and the ware is deposited on a conveyor 25 which takes it to a lehr 26.

Patent No. 2,409,284 is on a device for heating optical lenses and then hardening them by a blast of air. It is an invention of George W. Jackson who assigned it to American Optical Company of Southbridge, Mass. The apparatus comprises a heating furnace and means for supporting a lens therein and then moving the lens out of the furnace to an air blast for hardening. It is de-

(*Continued on page* 583)

CHECK THESE ADVANTAGES of TECO Oil Firing



1. High efficiency with three burners, two below and one above the port.
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Available also are TECO dual fuel installations which assure high efficiency, flexibility and economy of operation on either gas or oil and provide quick, easy means of changing from one fuel to the other.

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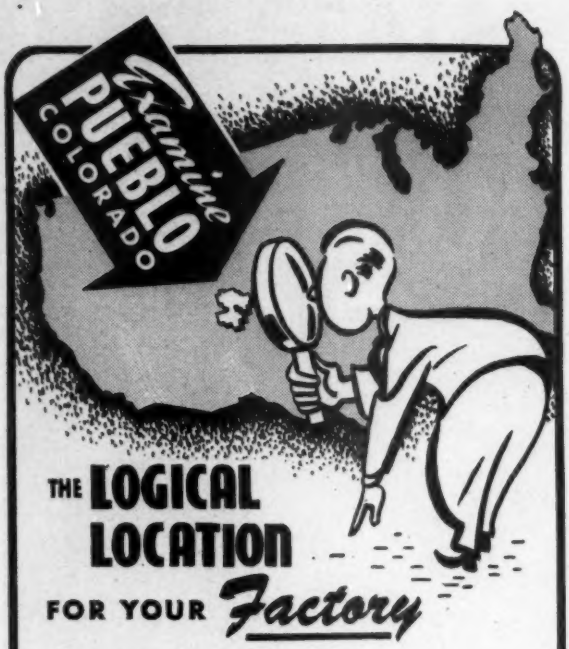

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OPTICAL SOCIETY MEETING . . .

(*Continued from page* 555)

PHENOMENA IN PHOSPHORS OF SHORT DURATION".

M. M. Blau and J. R. Carlin, International Rare Metals Refinery, "TEMPERATURE EFFECTS OF FLUORESCENCE AND PHOSPHORESCENCE PHENOMENA ASSOCIATED WITH IRRADIATIONS BY ALPHA PARTICLES".

Phase Microscopy

Phase Microscope will undoubtedly become a tool in the glass laboratory. H. Jupnik, H. Osterberg and G. E. Pride of the American Optical Company told of successful observations of specularly reflecting specimens, e.g. tiny scratches on highly polished unetched steel. In phase microscopy deviated and undeviated spectra produced by diffraction are separated in a plane located at the objective. The phase differences and amplitude differences instrumental in the separation of the spectra are modified at will in a new method called Polanret Microscopy by rotating the polarizer and analyzer introduced into the system at the exit pupil and between exit pupil and eye respectively. Papers:

H. Osterberg, "POLANRET MICROSCOPY".

H. Jupnik, H. Osterberg and G. E. Pride, "PHASE MICROSCOPY WITH VERTICAL ILLUMINATION".

New Echelette Grating in Spectroscopy

The audience gave a prolongated and well deserved ovation to Professor R. W. Wood who demonstrated what is the best replica grating known to date. An echelette grating concentrating on spectral orders higher than 20 breaks up a spectrum of enormous length into, e.g. 12 narrow superposed spectra simultaneously seen one above the other in a telescope field of 3″ aperture and 36″ focus resolves lines of 0.3 A° separation. Paper:

R. W. Wood, "CONCAVE REPLICA GRATINGS AND A NEW METHOD OF EMPLOYING ECHELETTES".

The impressive program on Spectroscopy, in which infra-red work predominated, also comprised:

R. C. Gore, R. S. McDonald and Vanzandt Williams, "COMPARISON OF LiF AND CaF_2 PRISMS FOR INFRA RED USE".

A. H. Pfund, "IMPROVED SELENIUM POLARIZER FOR THE INFRA RED".

D. S. McKinney, "A CALIBRATION METHOD FOR INFRA-RED PRISM SPECTROMETERS".

J. Strong, "A NEW GALVANOMETER FOR RADIOMETRIC MEASUREMENTS AT LOW FREQUENCIES".

E. K. Plyler, R. Stair, and C. J. Humphreys, "THE INFRA RED ABSORPTION SPECTRA OF TWELVE CYCLOPENTANES AND CYCLOHEXANES".

Other Subjects: Vision, Color, Light Sources

The rest of the meeting was organized into three sessions on vision, color and light sources. Glass Technologists expect to be informed on progress in color science at a symposium to be organized at the April meeting of the Ceramic Society.

List of Papers:

(*Continued on page* 581)

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In the analysis of sand, clay, lime and ash, or in other key tests and determinations, every step of chemical control in today's glass and ceramics laboratories calls for unerring accuracy. There the chemist working with the precision tools of his profession safeguards quality all the way from acceptance of raw materials on through to certification of finished products.

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BALL BROS. NO. 1 FACTORY . . .

(*Continued from page* 551)

The underground belt conveyor to transfer cullet from the lehrs back to the batch system (not yet in operation) promises to be a marked improvement over the present method of trucking it to the crusher in metal drums. Here again the measure of economy is quite obvious.

The new building is lighted throughout with forty-eight inch, twin tube fluorescent lights, some in staggered

New plant cafeteria located on second floor of new building. 2,000 to 3,000 meals are served daily.

rows and some in straight rows, ranging from four feet to twelve feet apart each way. Metal sash windows are installed in all side walls on both the first and second floors to admit all possible daylight.

A very complete heating system has been installed, using the over-head blower type steam unit.

The gas meter room, a penthouse type of brick construction, is located on the flat deck roof between the carton storage and the forming department at the west side of the building, and is accessable from an all steel stairway built from the ground up to the deck on the outside of the building. The trunk gas main comes into this room. A master shut-off valve controls the flow of gas to all the smaller tributary lines to the furnaces, or the flow may be cut off entirely by this master valve. Formerly this trunk main came into the basement under the furnace department, an arrangement which involved risk in reaching the master shut off valve in event of a leak, particularly in case of fire.

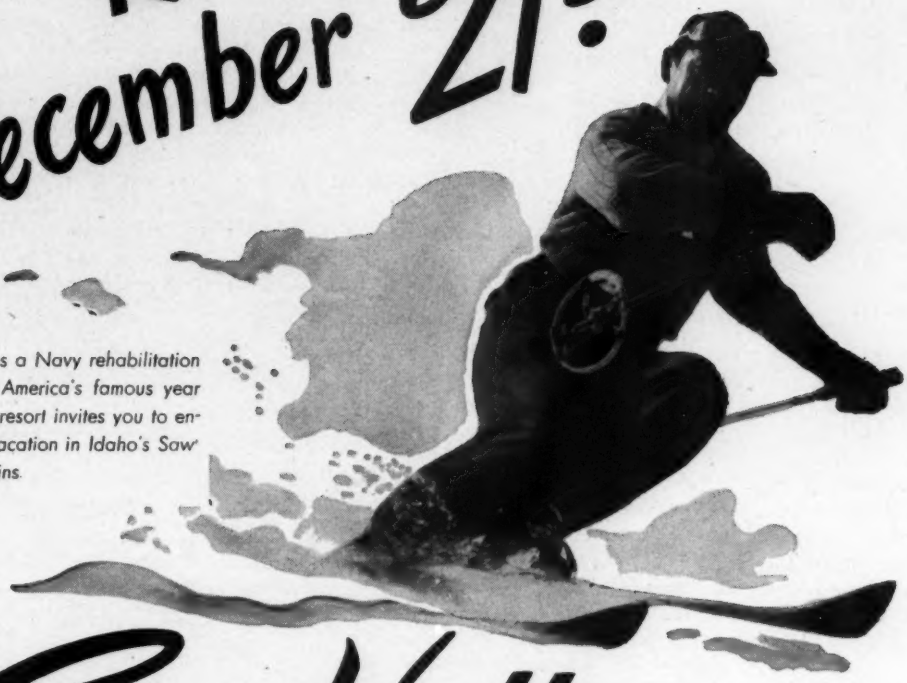
The switch gear room is of the same type of construction as that of the gas meter room. It's location is also on the flat deck roof between carton storage and the forming department, but at the east side of the building. It, too, is accessable from an all steel stairway from the ground up to the deck on that side of the building. Like the gas meter room, this switch gear room (not yet equipped) will have trunk lines coming in and master switches to control the flow of electric current to all sections of the building.

The location of the gas meter room and the switch gear room places the control of both gas and electricity on the outside of the building and can be reached under any circumstances without entering the building.

The building throughout is constructed of fireproof materials and has been built to be as fire proof as possible without hampering the operations of production.

UNION PACIFIC RAILROAD SERVES SUN VALLEY

Re-opens December 21st



Its war duty as a Navy rehabilitation center ended, America's famous year 'round sports resort invites you to enjoy a winter vacation in Idaho's Saw tooth Mountains.

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WINTER SPORTS UNDER A "SUMMER SUN"

(*Continued from page* 559)

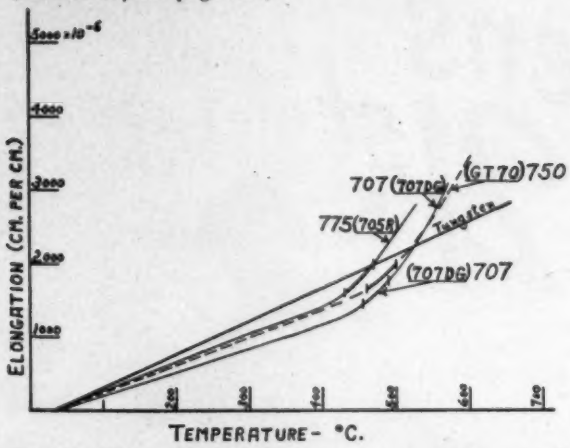

Fig. 27. Thermal expansions of glasses sometimes used with tungsten.

siderably separated expansion curves. Such differential cooling in some cases may, if performed with care, offer a means of obtaining a desired stress other than that which results from natural cooling.

(8) *Copper and Glass.* As seen in Figure 30 copper does not approach a match with either soft or hard glass. Consequently, it is necessary to employ a thin-edge seal, a thin disc seal, or a thin ribbon seal. The thin-edge seal can vary somewhat but the following proportions have been found successful: (1) 0.003 in. thick at the thin edge, taper of 1.2° running back from this edge to the full thickness of the metal; (2) 0.002 in. thick at the thin edge, taper of 0.7° running back from this edge to the full thickness; and (3) thin edge as in either case above, taper as above for distance of about one-half inch, then double the above taper for another half inch, followed by triple the above taper if the metal thickness is large. The glass-metal overlap is usually about a quarter inch or less.

The thin edge makes it possible to use any glass. Since this is so, hard glasses are nearly always used because of better thermal and electrical properties.

Thin-edge tubular seals are often inside seals and often outside seals. In some cases inside-outside seals are used. An inside seal resists sudden cooling much better than an outside seal. An outside seal, on the other hand, resists sudden heating much better than an inside seal. An outside seal is less liable to damage in handling because the free edge of the glass is inside the seal. There is more danger of overheating the outside seal during manufacture because the heat must reach the glass by transmission through the copper.

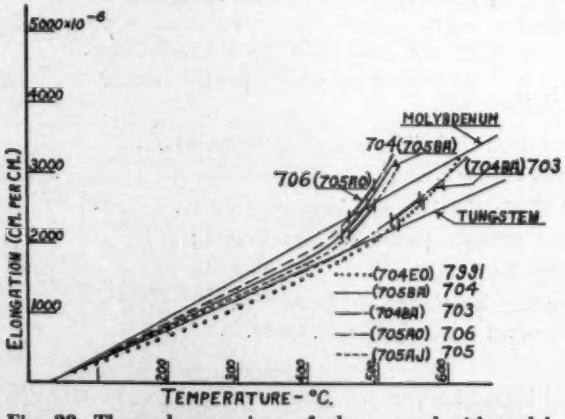

Fig. 28. Thermal expansions of glasses used with molybdenum, with expansion curve of tungsten to show relationship.

Disc seals with copper may be made with metal up to 0.030 in. thick for a diameter of one inch. Except in cases of extremely thin metal it is usually necessary to have nearly identical seals on both sides of a disc. One seal may be a butt seal with glass tubing and the other side may be another butt seal with glass tubing or it may be a torus of glass making approximately the same contact with the metal as the tube on the other side. Care must be taken to see that glass does not run over the edge of the metal disc.

Ribbon seals with metal up to 0.015 in. thick have been made by shaping the edges of the ribbon so that in cross-section the metal is a parallelogram with two acute angles of about 10°.

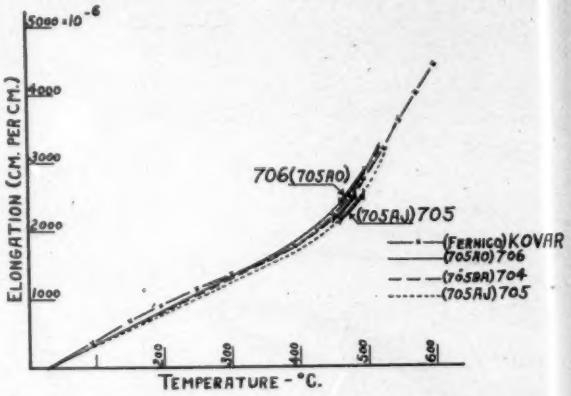

Fig. 29. Thermal expansions of Kovar and its matching glasses.

Conclusions

The technology of glass-metal seals has been almost entirely empirical for many years. Almost unbelievable ingenuity has been employed in developing methods of sealing materials of considerable disparity on a production basis, and the pioneers in the art are deserving of the greatest praise. Without their efforts the physicists and engineers who have built up the amazing and ever-expanding field of electronics could have done nothing since electrons perform useful work only when there are few air molecules to be pushed and jostled. Even that commonplace miracle, the electric light bulb, would not be available at a cost of almost nothing per hour of useful life if platinum were still the only usable sealing metal.

In spite of some slight progress away from empiricism in the past ten or fifteen years there is yet much to be discovered. It is likely that the next five years will bring a welcome attack on many problems which require only systematic investigation for full solution. This does not mean that strikingly new metals, alloys, glasses, or designs are to be expected. The need, rather, is for fundamental knowledge on behavior of glasses, mechanism of wetting and adherence, causes of deterioration of seals

(*Continued on page* 578)

Date Gardens of Furnace Creek Ranch, Death Valley Monument, California

The transformation of desert land by modern methods of irrigation, into a virtual Garden of Eden, is demonstrated by the Date Gardens of Furnace Creek Ranch, Death Valley Monument, California.

Some years back, it was recognized by the United States Department of Agriculture, that Death Valley (home of 20 Mule Team Borax) was free of a parasite known to attack date palms in every other locality throughout the world. These parasites materially reduce the crop yield and otherwise damage the fruit.

Experimental date gardens were planted by the Pacific Coast Borax Company in cooperation with the Department of Agriculture and have long since proven of inestimable value for the many thousands of cuttings produced and planted in other areas.

The harvesting of the cuttings is the primary purpose of these date gardens, yet the fruit is of excellent quality, well formed, lighter in color as compared to the fruit from the far east and is also characteristically less moist. Death Valley dates are considered choice and highly desirable.

MECHANICAL SHOCK—Practically all glass articles are subjected to various mechanical shocks either through handling, washing, and transporting or even during normal intended use. The composition of a glass is a determining factor in its ability to withstand such shocks. B_2O_3 as a constituent will increase the tensile strength and elasticity of a glass thus making it more shock resistant.

Another good reason why Borax should be used as an essential ingredient in the batch formula.

Our representatives are prepared to discuss the special advantages of B_2O_3 in glass.

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(*Continued from page* 576)

in operation, the true meaning of electrolysis in glass, and numerous others. Until such fundamental knowledge is available a major portion of glass-metal seal technology will continue to come under the heading of "trial and error." It is hoped that the information collected and summarized in the preceding pages will not only prove useful in itself but will be suggestive of many new investigations and projects.

Addendum

Since preparation of the section, Stresses in Glass-Metal Seals (pages 502-03), a discussion of stresses in external seals has appeared[55]. The treatment is applicable only to the central portion of a seal comprising a solid glass cylinder sealed to the inside of a metal cylinder. The ends are not considered since shearing stresses exist in these zones.

Equations (2), (3), (4), and (5) already given (see page 502) can be used to represent the stresses of the inner cylinder if four simple relations are employed, as follows:

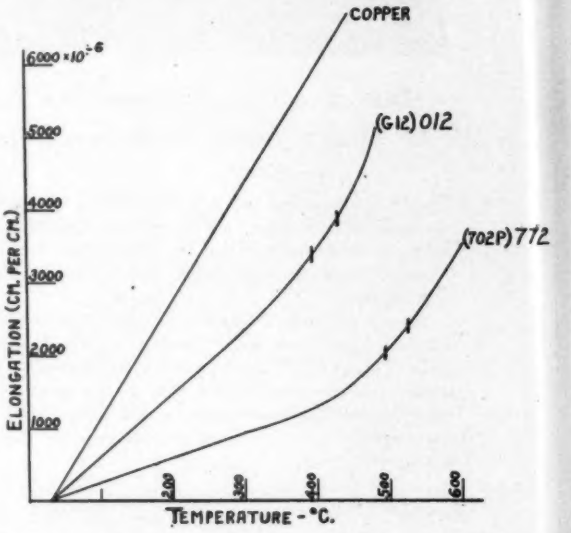


Fig. 30. Relationship between expansions of copper and hard and soft glasses.

(a) The stresses in the glass cylinder are all of the same sign, tension or compression.

(b) Radial stress is the same for inner and outer cylinders at the glass-metal interface and is constant throughout the inner cylinder.

(c) Tangential and radial stresses are equal in the inner cylinder.

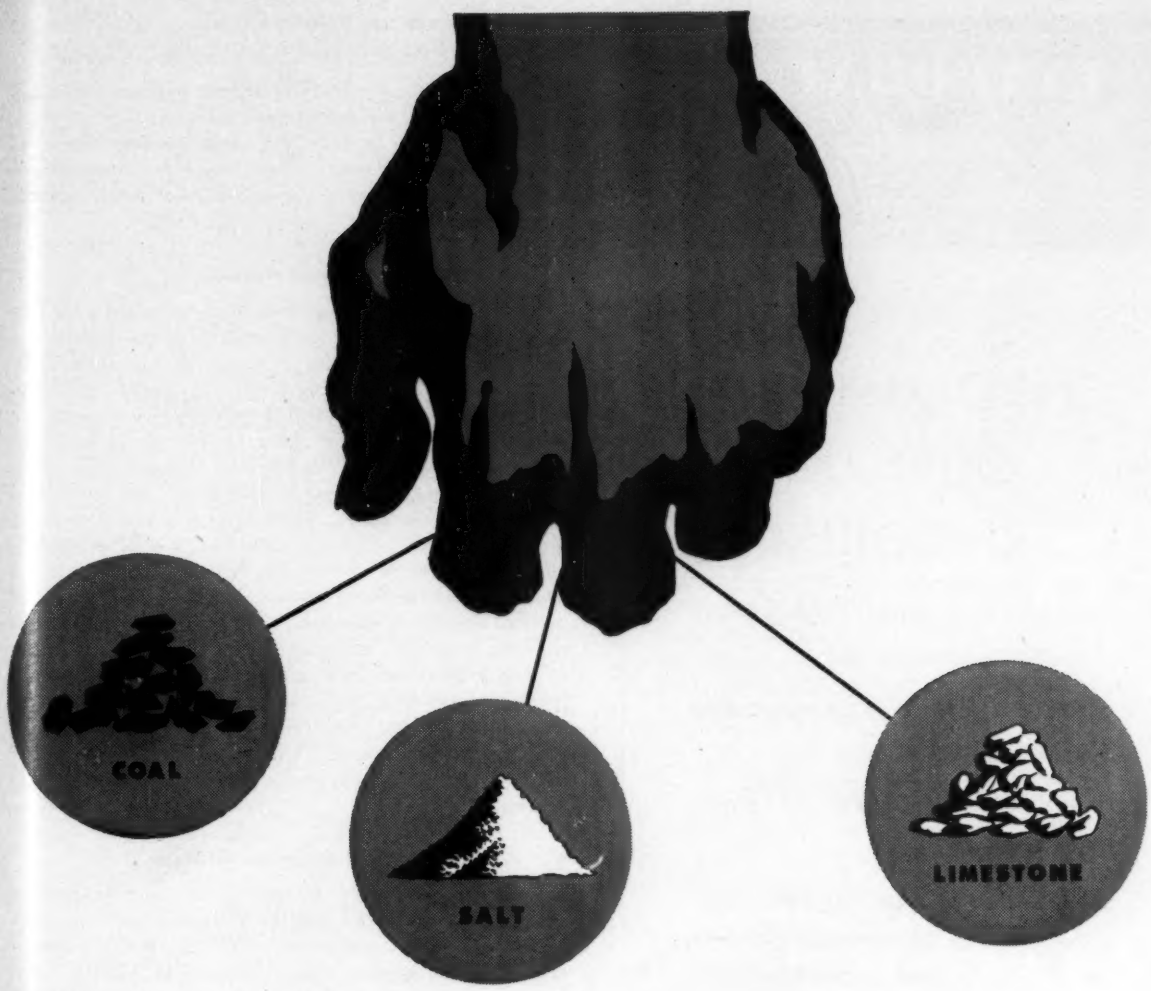
(d) The axial stress in the glass cylinder of radius a is related to the axial stress in the metal cylinder of outside radius b as follows:

$$p_{z1} = -\frac{b^2 - a^2}{a^2} p_{z0}$$

By substitution of the proper values of E_1 in equations (3) and (5) and utilizing the above relations be-

(*Continued on page* 582)

55. Hull, A. W., *J. Appl. Phys.*, 17, 685-87 (1946)



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GLASS-FORMING SUBSTANCES . . .

(*Continued from page* 554)

As in the case of the fluoride, the polymer $(PNCl_2)_n$ also forms a rubberlike vitreous substance.

There are no data on the glass-forming nature of bromides and iodides. Silver chloride, bromide, or iodide, however, form a glassy substance under quenching conditions.

IV. Sulfide and Related Glasses

Sulfide glasses are similar to oxide glasses except that very few of them are glass-formers and the sulfides are gradually oxidized in air. A glassy CS_2 was obtained by Bridgman[5] by compressing liquid CS_2 under high pressure. It is not known whether this glassy substance is a glass. SiS_2 is probably not a glass-former because its structure is entirely different from that of SiO_2 (Zintl and Loosen[47]), even though Silverman[35] has speculated on a thiosilicate glass. GeS_2, however, has a structure similar to that of SiO_2, according to Zachariasen[45], which indicates the possibility of glass formation. A search of the literature reveals that Pugh[30] has reported an amber-colored glass of pure GeS_2. The author has also made a GeS_2 glass and other sulfide glasses containing germanium in a nitrogen-filled furnace. Tammann[39] stated that As_2S_3 and Sb_2S_3, among other sulfides, form a glass. According to Mellor[26], As_2Se_3 melts to an amorphous solid. Tl_2Te obtained from reduction of Tl_2TeO_4 also yields a clear lemon yellow glass, as recorded by Mellor[26].

V. Mixed and Miscellaneous Glasses

From the preceding discussion, it naturally follows that glasses can be formed by "compounding" the various types of glass mentioned. Thus, we have halogeno-oxide, oxy-halogenide, etc. The general rules governing the formation of oxide glasses are approximately true for these mixed glasses. Among the mixed glasses, the fluoroxide glasses are probably the most important. The author has synthesized a large number of fluoroxide glasses of practical value. He has also made some chlor-, bromo-, and iodo-oxide glasses. Chloro-oxide glasses have also been made by Majumdar and Sarma[24].

Luyet[21] reported that the solution of any substance which is soluble in water in the proportion of about one to four could be vitrified when immersed, in layers, in liquid air. Solutions of sodium chloride, potassium hydroxide, calcium nitrate, sodium hyposulfite, etc., have been made into glasses.

Conclusion

The foregoing discussion serves as a brief review of the present knowledge of the inorganic chemistry of glass formation. It also serves as a reminder to investigators in the field of the need for a comprehensive, systematic and quantitative study of the subject. Such a study is not only important from a theoretical point of view, but it will also pay dividends in the development of many new and useful glasses hitherto unknown.

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(*Continued from page* 572)

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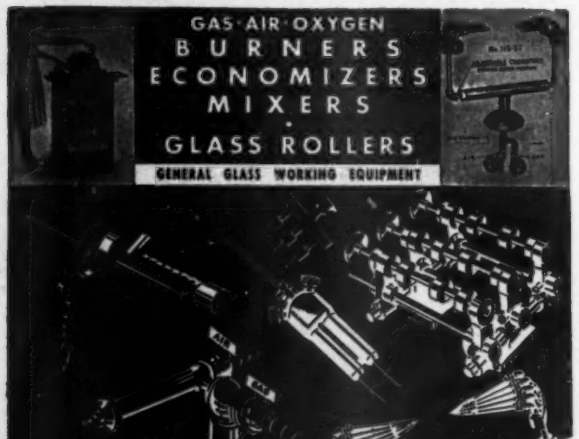

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GLASS - METAL SALES . . .

(*Continued from page* 578)

tween stresses it is possible to construct a chart, similar to Figure 16, to express the stresses in terms of ratio of metal to glass radii. All such relationships, however, are subject to the limitations and inaccuracies previously discussed. Further modification may be necessary if the external seal is part of a combination seal.

Acknowledgements

Assistance in assembling the technical data and illustrations in this paper has been received from many sources. Particular acknowledgement is due the Radio Corporation of America for tube illustrations, the Corning Glass Works for information on the properties of their glasses and thermal expansion data, and Stupakoff Ceramic and Manufacturing Company, Allegheny Ludlum Steel Company, Driver-Harris Company, Carpenter Steel Company, and Scomet Engineering Company for information on metals and alloys.

Errata

Page 392, last paragraph under E. Butt Seals, fourth line: *end caps* instead of *and caps*.

Page 394, Properties of Glasses: last line of previous section to be transposed to follow first line of this section.

Page 414, equation below Table 4: should read $R = 0.1752\ Cds$.

Page 447, Table 5, heading for third column from left: should be *cm/cm/°C*.

Page 470, right-hand column, next to last paragraph, fourth line: read *electron gas* instead of *electron glass*.

Page 476, right-hand column, next to last paragraph: first sentence should read *Beading is rarely used with soft glasses since the borax coating on Dumet wire serves somewhat the same purposes.*

INVENTIONS & INVENTORS . . .
(*Continued from page* 570)

signed for use in small shops having small production instead of large factories having mass production.

Figure 5 shows at the top a view of the apparatus with the lens in the furnace for heating and below, a similar view with the lens withdrawn for hardening by an air blast. A boxlike furnace 7 has refractory walls which support suitable electrical heating elements. On the sides of the furnace there are slideways 14 which receive bars 15, these bars being connected by a cross piece 16. This cross piece carries a work supporting rod 17 which is shown in the lower figure as withdrawn from the furnace. The rod 17 carries two closure members, one 27 which closes the opening to the furnace when the lens is inside, and a similar one which closes the opening when the lens is outside for hardening. The means for supporting the lens on the rod 17 comprises a grooved refractory block to receive the bottom of the lens and a clamp lever 34 to engage the top of the lens 33 and to hold it in place. The upper part of the figure shows the lens being heated and the furnace opening closed by the door 27.

The support for the furnace is formed by a housing 38 which contains a blower which discharges air through pipes 44. These pipes are so positioned that when the heated lens is withdrawn, as shown in the lower part of the figure, a blast of air will be directed onto each side of the lens. A pyrometer 46, switch 47 and temperature control 48 are conveniently placed on the front of the housing 38.

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